Fisheries and Oceans Canada | Pêches et Océans Canada

NOAA FISHERIES

CERT

Comité d'évaluation des ressources transfrontalières

Document de référence 2005/03

Ne pas citer sans autorisation des auteurs

TRAC

Transboundary Resource Assessment Committee

Reference Document 2005/03

Not to be cited without permission of the authors

Assessment of Haddock on Eastern Georges Bank

L. Van Eeckhaute[1] and Jon Brodziak[2]

[1]Fisheries and Oceans Canada
531 Brandy Cove Road
St. Andrews, New Brunswick E5B 2L9
Canada

[2]NOAA/NMFS/Northeast Fisheries Science Center
166 Water Street
Woods Hole, Massachusetts 02543-1097
USA

Ce document est disponible sur l'Internet à : This document is available on the Internet at :
http://www.mar.dfo-mpo.gc.ca/science/TRAC/trac.html

Canada

106-07192/

ABSTRACT

The total catch of eastern Georges Bank haddock in 2004 was 11,790 mt under a combined Canada/USA quota of 15,000 mt. The 2004 Canadian catch increased from 6,873 mt in 2003 to 9,838 mt while the USA catch increased from 1,627 mt in 2003 to 1,952 mt. Estimated discards from the Canadian scallop fishery and USA groundfish fishery were revised from the previous assessment and were very low relative to the total catch. Eastern Georges Bank haddock catches fluctuated around 5,000 mt during 1985-1990. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,100 mt in 1995, averaged about 3,600 mt during 1996-1999 and have increased since then.

Adult population biomass has steadily increased from near an historical low of about 9,000 mt in 1993 to about 74,000 mt in 2003. Adult biomass subsequently decreased to about 50,000 mt at the beginning of 2005 but is projected to increase after 2006 to well beyond the 1931-1955 maximum biomass of about 90,000 mt. The 2003 year class is estimated to be 365 million age-1 fish. Although the current estimate is substantially lower than the previous year's estimate, the 2003 year class is still estimated to be the largest ever observed in the assessment time series. The 2000 and 1998 year classes are also strong. In contrast, the 2001 and 2002 year classes are weak and initial estimates of the 2004 year class suggest it is also relatively weak. Fishing mortality has been below the reference threshold (F_{ref}) of 0.26 since 1995. Reduced fishing mortality and lower bycatches of juveniles have increased haddock survival rates and led to greater abundance of older fish. The population age structure shows full representation of all age classes. Productivity has diminished in recent years due to reductions in average fish size at age.

With an assumed total catch of 23,000 mt in 2005, a combined Canada/USA catch of 22,000 mt in 2006 would result in a neutral risk (50%) that fishing mortality in 2005 would exceed F_{ref}. A catch of 18,000 mt would result in a low risk (25%) that fishing mortality in 2005 would exceed F_{ref}. Catches in 2007 are expected to increase substantially as the 2003 year class becomes more fully recruited to the fishery.

RÉSUMÉ

En 2004, les prises totales d'aiglefin du banc Georges se sont chiffrées à 11 790 tm, par rapport à un quota combiné Canada/États-Unis de 15 000 tm. Les prises canadiennes, qui étaient de 6 873 tm en 2003 ont augmenté à 9 838 tm, tandis que les prises des États-Unis ont, elles aussi, connu une hausse, passant de 1 627 tm en 2003 à 1 952 tm en 2004. Le chiffre estimé des rejets de la pêche canadienne du pétoncle et de la pêche américaine du poisson de fond a été revu par rapport à l'évaluation précédente et ces rejets se sont avérés très bas par rapport aux prises totales. Les prises d'aiglefin dans l'est du banc Georges ont fluctué alentour de 5 000 tm de 1985 à 1990. Suite à l'adoption de mesures de gestion restrictives, les prises combinées du Canada et des États-Unis ont diminué, passant de plus de 6 500 tm en 1991 à un seuil d'environ 2 100 tm en 1995, puis elles se sont situées en moyenne alentour de 3 600 tm de 1996 à 1999 et elles ont augmenté depuis.

La biomasse de la population adulte a constamment augmenté après être tombée à environ 9 000 t, presque un seuil historique, en 1993 et elle s'est chiffrée à environ 74 000 tm en 2003. Elle a ensuite diminué à environ 50 000 tm au début de 2005, mais on prévoit qu'elle augmentera après 2006, au point de se situer bien au-delà de la biomasse maximale de la période 1931-1955, soit environ 90 000 tm. On estime que la classe d'âge de 2003 est d'environ 365 millions de poissons d'âge-1. Bien que cette estimation soit sensiblement plus basse que celle de l'an dernier, elle fait encore de la classe d'âge de 2003 la plus grande classe d'âge observée dans la série chronologique de l'évaluation. Les classes d'âge de 2000 et 1998 sont également fortes. En revanche, celles de 2001 et 2002 sont faibles, tandis que les estimations initiales de la classe d'âge de 2004 laissent croire qu'elle est aussi relativement faible. La mortalité par pêche s'est située sous le seuil de référence (Fréf) de 0,26 depuis 1995. La baisse de la mortalité par pêche et des prises accessoires de juvéniles ont accru les taux de survie de l'aiglefin et abouti à une plus grande abondance de vieux aiglefins. Toutes les classes d'âge sont pleinement représentées dans la structure d'âges de la population. La productivité a baissé ces dernières années par suite de la diminution de la taille moyenne du poisson selon l'âge.

Si on se fonde sur des prises hypothétiques totales de 23 000 tm en 2005, des prises combinées Canada-États-Unis de 22 000 tm en 2006 se traduiraient par un risque neutre (50 %) que la mortalité par pêche en 2005 soit supérieure à Fréf. Des prises de 18 000 tm se traduiraient par un faible risque (25 %) que la mortalité par pêche en 2005 dépasse Fréf. On s'attend à ce que les prises augmentent notablement en 2007 en raison du plein recrutement à la pêche de la classe d'âge de 2003.

INTRODUCTION

Since 1990, Canada uses eastern Georges Bank, statistical unit areas j and m in NAFO sub-division 5Ze (Figure 1), as a haddock management unit (Gavaris 1989), referred to as "5Zjm". Canada and the USA jointly develop management measures for Georges Bank transboundary stocks including haddock. The 5Zjm management unit was adopted as the basis for a harvest allocation proposal for the two countries (DFO 2002). This assessment applies the approach used by Van Eeckhaute and Brodziak (2004) using Canadian and USA fisheries information updated to 2004. Results from the Fisheries and Oceans Canada (DFO) survey, updated to 2005, and the USA National Marine Fisheries Service (NMFS) surveys in the spring, updated to 2005, and fall, updated to 2004, were incorporated.

FISHERY

Commercial Catches

Haddock on Georges Bank have supported a commercial fishery since the early 1920s (Clark et al 1982, Gavaris and Van Eeckhaute 1998). Catches during the 1930s to 1950s ranged between 15,000 mt and 40,000 mt (Figure 2), averaging about 25,000 mt (Schuck 1951, R. Brown pers. com.). Records of catches by unit area for the early 1960s period have not been located, however, based on records for NAFO Subdivision 5Ze, catches probably attained record high levels of about 60,000 mt during the early 1960s. Catches in the late 1970s and early 1980s, ranging up to about 23,000 mt, were associated with good recruitment. Substantial quantities of small fish were discarded in those years (Overholtz et al 1983). Catches subsequently declined and fluctuated around 5,000 mt during the mid to late 1980s. Under restrictive management measures, combined Canada/USA catches declined from over 6,500 mt in 1991 to a low of about 2,100 mt in 1995, fluctuated between about 3,000 mt and 4,000 mt until 1999 and increased to 11,790 mt in 2004 (Table 1, Figure 3). In 2004, the Canadian catch was 9,838 mt and the USA catch was 1,952 mt under quotas of 9,900 mt for Canada and 5,100 mt for the USA.

Quotas are the principal means used to regulate the Canadian groundfish fisheries on Georges Bank. Canadian catches since 1995 were below the quota due to closure of some fleet sectors when the cod quotas were reached, except for the year 2000 when the catch of 5,402 mt was slightly above the Canadian quota of 5,400 mt. Quota regulation requires effective monitoring of fishery catch. Weights of all Canadian landings in 2004 were monitored at dockside and at-sea observers monitored 12% by weight of the haddock caught in 2004. Discarding and misreporting of haddock by the groundfish fishery have been considered negligible since 1992. During 1994-2004, all Canadian groundfish fisheries on Georges Bank were closed from January to early June.

In recent years, the Canadian fishery has been conducted primarily by vessels using otter trawls and longlines with some handlines and gillnets. During 2004, otter trawlers under 65 ft and fixed gear vessels 45-65 ft operated on individual quotas while fixed gear vessels under 45 ft operated on community quotas administered by local boards (Table 2). Vessels over 65 ft operate on Enterprise Allocations, which are company quotas. Smaller vessels are allowed to fish the quota which has been allocated to the larger vessels under the Temporary Vessel Replacement Program (TVRP) and increasing amounts of this quota have been taken by the TVRP boats in recent years. In 2004, 80% of the catch was taken by tonnage class 2 and 3 (less than 150 tons) vessels less than 65 ft in overall length. Otter trawls took 80% of the

haddock and longliners took 20% (Table 3). The highest catches in 2004 occurred during July and August (Table 4, Figure 4).

Canadian landings until 1995 include those catches reported by the scallop fishery but, since 1996, this fishery has been prohibited from landing haddock and this species was then discarded. Landed haddock bycatch, when landings were allowed, was low with a maximum of 38 mt reported in 1987 (Table 3). Estimates of scallop fishery discards were revised from what was reported in the previous assessment (Van Eeckhaute and Brodziak, 2004). Discards of haddock for 1969 to 1995 by the Canadian scallop fishery were estimated from scallop effort data and a discard per scallop gear tow-hour estimated from eight observed scallop trips conducted during 1991 to 1995. No scallop effort data was available for 1969 to 1971 so discards were estimated using the haddock discard rate per scallop landed estimated from the same eight observed scallop trips and prorated to the total scallop landings for these three years. Discards ranged between 69 and 186 mt from 1969 to 1995. Discards of haddock from this fishery for 1996 to 2004 were estimated from scallop effort data and bycatch rates from five observed trips conducted in 1995, 1996, 1997 and 1998 and from eight observed trips in 2001, three in 2002 and five in 2004. A seasonal component was apparent from the 2001, 2002 and 2004 trips and was incorporated into the bycatch rates for 1996 to 2004. In these years the discard estimates ranged between 29 and 102 mt, lower than most values reported before 1996 due to lower effort in the scallop fishery. Greater detail on the methods and results can be found in Van Eeckhaute et al 2005.

USA haddock catches for 2004 were derived from mandatory dealer reports and fishing vessel logbooks using the same procedures as for 1994-2003. The USA fishery has been regulated using trawl mesh size increases, closed areas, days-at-sea limits, daily catch limits and trip limits (Table 2). Trip limits were introduced in 1994 and daily catch limits in 1996 to reduce fishing mortality. Low trip limits in the mid-1990s resulted in an increase in discards which were included in the USA catch at age data for 1994 to 1998. Trip limits have been increased periodically to reduce discarding of haddock and improve haddock yields. Otter trawl gear accounted for the vast majority of USA discards (>99%) while other gears such as scallop dredges, accounted for less than 1% of the total USA haddock discards. Discards have remained low because of high trip limits combined with larger trawl mesh size. Discards for 2001 to 2003 were estimated at 40, 35 and 63 mt, respectively and are included in the catch at age. The combination of area closures, effort restrictions, and trip limits reduced USA fishing effort in 5Zjm, with the result that USA catches from 5Zjm were relatively low from 1993 to 2000. Even though Area II was closed, landings from 5Zjm, which come almost exclusively from tonnage class 3 and 4 otter trawlers (51 to 500 tons), nearly tripled from 604 mt in 2001 to 1,796 mt in 2004, averaging 1,200 mt during 2001-2004 (Table 5). In 2004, due to limits on the cod quota, 5Zjm was closed to USA groundfish vessels on Oct. 1. A haddock Special Access Program (SAP) was in place from Nov. 19 to Dec. 31 which allowed fishing outside of Closed Area II. As a result, catches were much lower than the USA quota of 5,100 mt and were 1,952 mt, of which 156 mt were estimated as discards. USA catches by month have not been available since mandatory reporting began in 1994 (Table 6). Quarterly USA landings totals in 2004 were: 266 (15%), 1196 (67%), 309 (17%) and 25 mt (1%) (Table 7). USA landings were divided into 372 mt (21%) large, 1411 mt (79%) scrod and 12 mt (1%) unclassified market categories.

Size and Age Composition

The size and age composition of the 2004 Canadian groundfishery was characterized using port and at-sea samples from all principal gears and seasons. Comparison of port and at-sea length frequencies did not reveal any persistent differences (Figure 5), therefore, all data

were combined (Table 8). The size composition of catch in the Canadian fisheries peaked at 50.5 to 52.5 cm (20-21 in) for otter trawlers and at 54 cm (21 in) for longliners (Figure 6). Gill-netters caught few haddock but these fish were larger. The percentage of haddock below 43 cm was less than 1% in the groundfish fishery.

Scallop fishery discards in 2004 quarters (Q) 3 and 4 could be characterized by length samples obtained by observers on trips conducted during August to December. To characterize all other time periods, a comparison was conducted between relevant survey and groundfishery length frequencies and the available haddock length frequencies from observed scallop trips (Figure 7). Scallop fishery length frequencies obtained by observers were available from 1995 (Q1), 2001 (Q2,3,4) to 2002 (Q1,2) and 2004 (Q3,4). The 1995, 2001 and 2002 data were compared to those from the survey area which most closely matched the scallop dredge fishing locations. For example, the 1995 dredge sets occurred almost exclusively in area 5Zj so only survey sets made in 5Zj, stratum 5Z2 were used for comparison. The 2004 scallop dredge data were compared to the length frequencies from DFO and NMFS spring and fall surveys and the Canadian groundfishery data in the 5Zjm area. The quarter 1 comparisons indicated that scallop dredges failed to capture the smaller haddock observed in the surveys but this may be due to a lack of spatial coverage of the dredge data and the limited amount of data available from the scallop fishery since comparisons from other quarters show similar selectivity between survey and scallop dredge gear. Survey and scallop gear length frequencies were most similar for quarters 3 and 4 for which the greatest amount of data were available. The comparisons indicate that the size composition of the haddock taken in scallop gear is more similar to that in the surveys than to the commercial groundfish gear. Therefore, except for 2004 quarters 3 and 4, in which adequate sampling was conducted, survey age composition was used to characterize the age composition of the scallop fishery discards. The average age composition of the DFO and NMFS spring surveys were used to characterize quarters 1 and 2 and the NMFS fall survey was used for quarters 3 and 4. The annual scallop fishery haddock discards are presented in Table 9.

Quarterly length samples from USA 5Zjm landings in 2004 were used to characterize the fishery length composition. Since no scrod samples were collected in quarters 1 and 4 and no large samples in quarter 4 (Table 7), size composition data were augmented by length samples from adjacent areas (522 (5Zh) and 525 (5Zn)) with similar size compositions for these quarters. Quarterly age samples were also used to characterize the fishery age composition. USA age composition data were augmented with 2004 DFO survey data for quarter 1 and with the 2004 Canadian commercial fishery age length keys for quarters 2, 3, and 4. The weight composition of the USA 5Zjm landings by market category was 21% large, peaking at 64 cm and 79% scrod, peaking at 53 cm, compared to 42% large and 58% scrod in 2003.

USA discards of eastern Georges Bank haddock in 2001 to 2004 were computed using quarterly age-length keys applied to quarterly discard length frequencies collected by at-sea observers. Approximately 9% of USA landings of eastern Georges Bank haddock were sampled by at-sea observers in 2004 involving a total of 936 otter trawl hauls and 16 other fishing operations. As in recent years, the vast majority of USA discards was attributable to otter trawl gear (>99%). Overall, USA discards of eastern Georges Bank haddock totaled 323.5 thousand fish in 2004. Of these, roughly 51% were age-1 fish from the exceptional 2003 year class.

Ages of survey and commercial-caught haddock were separately assigned by the DFO and the NMFS age readers, L. Van Eeckhaute and S. Sutherland, respectively. Intra-reader agreement tests for the DFO reader were not conducted in 2004 but testing conducted in 2003 indicated that age interpretations were internally consistent (Van Eeckhaute and Brodziak 2004). NMFS testing was conducted on data from the 2004 fall and 2005 spring NMFS surveys,

USA commercial landings in 2004 by quarter and a haddock otolith reference collection. The tests involved a total of 393 otoliths. Precision levels ranged between 91 and 98% agreement between first and second readings with no pattern of seasonal bias, as was observed in the previous years testing, indicating a high level of consistency in age determinations. Agreement matrices are presented in Appendix A, Tables A1 to A7. Inter-reader testing between the NMFS reader and the DFO reader was completed in 2005 for 50 otoliths from the DFO 2004 spring survey and 50 otoliths from the Canadian commercial fishery. Agreement was very good at about 96% (Tables A8 & A9). Age reader agreement was judged to be satisfactory for estimating catch at age.

The 2004 Canadian and USA landings at age estimates by quarter (Table 10) were added to the 1969-2003 catch at age data (Van Eeckhaute and Brodziak 2004). The Canadian 2002 and 2003 and USA 2001 to 2003 landings at age were revised to reflect updated landings. Canadian discards and USA discards for 2001 to 2004 were also included. Combined Canada/USA annual catch at age and average Canadian fishery weights at age are summarized in Tables 11 and 12 and Figures 8 and 9. The 2000 year class (age 4) and the 1998 year class (age 6) dominated the fishery in 2004 (Figure 10). In comparison to the USA catch the Canadian catch contained more younger haddock, i.e., about 20% more haddock aged 4. This reflects a difference in the time of peak catches between the two countries. The majority of the Canadian catch is taken in quarter 3 while most of the USA catch occurs in quarter 2. The proportion of age 4 haddock caught by Canada increased from 36% in quarter 2 to 56% in quarter 3 and 65% in quarter 4. Older age groups (ages 7, 8, and 9+) also contributed significantly to the 2004 catch (Figure 10). The age composition during the 1969 to 1974 period was atypical since it was dominated by the outstanding 1962 and 1963 year classes which continued to contribute substantially at ages 6 and older.

ABUNDANCE INDICES

Research Surveys

Surveys of Georges Bank have been conducted by DFO each year (February) since 1986 and by NMFS each fall (October) since 1963 and each spring (April) since 1968. All surveys use a stratified random design (Figures 11 and 12). For the NMFS surveys, two vessels have been employed and there was a change in the trawl door in 1985. Vessel and door type conversion factors (Table 13), derived experimentally from comparative fishing, have been applied to the survey results to make the series consistent. Additionally, two different trawl nets have been used on the NMFS spring survey, a modified Yankee 41 during 1973-81 and a Yankee 36 in other years, but no conversion factors are available for haddock (Forrester et al 1997).

The spatial distribution of catches by age group (1, 2, and 3+ for spring and 0, 1 and 2+ for fall) in the most recent surveys was plotted to show the distribution in comparison to the average over the previous 10 year period (Figures 13, 14 and 15). The 2003 year class at age 1 in the NMFS 2004 fall survey was abundantly and widely distributed as has been previously observed for large year classes. At age 2, the DFO 2005 February survey found this year class abundantly distributed on the northern edge, peak and southern flank while the NMFS 2005 spring survey found large catches on the northern edge and the southern flank. This year class was found in large quantities on the US side as well as the Canadian side, especially during the NMFS spring survey. The 2004 fall survey caught moderate catches of the 2004 year class at age 0 while catches of this year class at age 1 for both spring surveys were low. In fall, adult haddock are more concentrated in the deeper waters along the slopes of the Northeast Peak

and the Northern Edge. The 2004 fall survey got good catches of adult haddock in these areas. Large catches of adult haddock were observed on the Canadian side during the DFO 2005 spring survey. The NMFS 2005 spring survey caught fewer adults but they were somewhat more evenly spread out on both sides of the Bank, consistent with the trend usually observed for this survey.

Age-specific, swept area abundance indices show that the three surveys are consistent and track year class strengths well (Tables 14, 15 and 16; Figure 16). Some year effects are evident, however; for example, low spring catches occurred in both the 1997 DFO and NMFS surveys. All three survey series indicated that the 2003 year class is one of the strongest on record but spring survey catches in 2005 dropped substantially from the previous year. The NMFS fall survey gave a strong signal for the 2003 year class at age 1.

Survey biomass indices (ages 2-8 in fall; 3-8 in spring) peaked during the early 1960s (Figure 17). After declining to a record low in the early 1970s, they peaked again in the late 1970s, though at a lower level, and again during the mid to late 1980s at about half the level of the 1970s peak. Biomass generally increased during the 1990s. The DFO and NMFS spring 2005 biomass indices decreased substantially after being near record levels in 2004. A decrease was expected as the weak 2001 and 2002 year classes were anticipated to add very little biomass. The NMFS 2004 fall survey point was back up after showing a large drop in biomass in 2003.

Survey recruitment indices in 2003 and 2004 (ages 0 and 1) suggested that the 2003 year class was as abundant as the outstanding 1963 year class (Figure 18). However, survey results in 2005 indicate that this year class is not as large as initially indicated.

The abundance of the 2000 year class is comparable to the strong 1975 and 1978 year classes, with the 1998 year class being the third strongest since the 1978 cohort. The 1996 and the 1999 year classes are comparable to the moderate 1983, 1985, 1987 and 1992 year classes. These year classes are considerably smaller than the strong 1975 and 1978 year classes and the exceptional 1963 year class. The 2005 survey results suggest that the 2004 year class may be somewhat stronger than the weak 2001 and 2002 year classes.

GROWTH

Fishery weights at age (Table 12, Figure 9) for ages 2 and 3 during the mid-1990s were generally higher than prior to the 1990s. This increase reflects a change in gear selectivity that occurred in the early 1990s. In 2004, fishery weights for all ages except age 1 declined from the low 2003 values and 2005 DFO survey weights also markedly declined (Table 17 and Figure 9). This trend in decreasing weights at age starter earlier for the older ages in both the fishery and DFO survey. The younger ages did not show this trend until about 2001. DFO survey lengths at age also show decreases and, except for age 5, declined in spring 2005 to their lowest values in the time series (Figure 19).

Average weights at age of haddock from the 1989, 1990 and 1991 year classes are higher than adjacent year classes in both the surveys and the commercial fisheries, giving the false impression of a declining trend in the years following. Weights at age from the DFO survey are considered beginning of year population weights and are calculated using the method in Gavaris and Van Eeckhaute (1998) in which weights observed during the survey are weighted by population numbers at length and age. Fishery weights at age are derived from the sampled lengths at age and a length-weight relationship (Waiwood and Neilson 1985). In some cases,

the mean weight at age in the catch was larger than the population mean weight at age at the beginning of the following year for the same cohort. This feature was mostly attributable to commercial fishery gear selectivity (Gavaris and Van Eeckhaute, 2000). However, some discrepancies in weights at age were more persistent and may be due to problems associated with the length-weight relationship and gutted-to-round weight conversion factors.

HARVEST STRATEGY

The Transboundary Management Guidance Committee (TMGC 2003) has adopted a strategy to maintain a low to neutral risk of exceeding the fishing mortality limit reference, F_{ref} = 0.26. When stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding.

ESTIMATION OF STOCK PARAMETERS

Calibration of Virtual Population Analysis (VPA)

The adaptive framework, ADAPT, (Gavaris 1988) was used to calibrate the virtual population analysis with the research survey data. An investigation of model formulations and model assumptions was conducted by Gavaris and Van Eeckhaute (1998). They provide details for the established model formulation and objective function used in this assessment. Based on this formulation it was assumed that observation errors for the catch at age data were negligible. Observation errors for the abundance indices were assumed to be independent and identically distributed after taking natural logarithms of the values. The annual natural mortality rate, M, was assumed constant and equal to 0.2. Similar model assumptions and methods were applied to the updated information here. Minor differences in the handling of zero terminal catches for a year class were implemented as a refinement to the software to afford more flexibility. The population abundance for the 9+ age group was calculated but not calibrated to the indices. In the first quarter of the first year, the 9+ abundance calculation was based on the assumption that the fishing mortality for the 9+ age group was equal to the population weighted fishing mortality for ages 4 - 8. In the first quarter of subsequent years, the 9+ abundance was calculated as the sum of the age 8 and age group 9+ abundances at the end of the last quarter of the previous year.

The VPA was based on quarterly catch at age, $C_{a,t}$, for ages a = 0, 1, 2...8, 9+, and time t = 1969.0, 1969.25, 1969.5, 1969.75, 1970.0...2004.75, 2005.00 where t represents the beginning of the time interval during which the catch was taken. In previous assessments the catch at age contained no age 0 haddock since none were caught in the groundfish fishery. The inclusion of discards from the scallop fishery introduced age 0 fish into the catch at age. The effect of adding age 0s to the catch at age was determined to be negligible and since the discards were poorly estimated and values were low, age 0 was set to zero in the analysis. Ages 1 and older discards were included in the catch at age. The effect on the population estimate of adding older discards was minimal. The population was calculated to the beginning of 2005.00. The VPA was calibrated to bottom trawl survey abundance indices, $I_{s,a,t}$, for

s = DFO, ages a = 1, 2, 3...8, time t = 1986.16, 1987.16... 2004.16, 2005.00

s = NMFS spring (Yankee 36), ages a = 1, 2, 3...8, time t = 1969.29, 1970.29, 1971.29, 1972.29, 1982.29, 1983.29...2004.29, 2005.00

s = NMFS spring (Yankee 41), ages a = 1, 2, 3...8, time t = 1973.29, 1974.29...1981.29

s = NMFS fall, ages a = 0, 1, 2...5, time t = 1969.69, 1970.69...2004.69

Since the population is calculated to beginning year 2005, the NMFS and DFO spring surveys in 2005 were designated as occurring at time 2005.00 The NMFS fall survey captures young of the year and that information is included as 0 group, but older haddock appear less available during this season. Survey indices for older ages where catches were sparse and where there were frequent occurrences of zero catches were not included (e.g., NMFS fall survey ages 6 and older and ages greater than 8 in the NMFS spring and the DFO surveys). Zero observations for abundance indices were treated as missing data as the logarithm of zero is not defined. During years when discarding was high, survey information was used along with interviews to obtain estimates of the USA catch. This lack of complete independence between catch and survey data does not influence population estimates but may deflate variance estimates marginally.

Statistical properties of estimators were determined using conditional non-parametric bootstrapping of model residuals (Efron and Tibshirani 1993, Gavaris and Van Eeckhaute 1998). Population abundance estimates at age 1 exhibited a relatively large potential bias, had a relative error of about 60% and a potential bias of over 10%, while the relative error for other ages was between about 25% and 40% with a potential bias between 1% and 7% (Table 18). The relative bias on fishing mortality for ages 4 and older in 2004 was small at about 2%. While trends in the three surveys are generally consistent, the survey indices exhibit high variability and the average magnitude of residuals is large relative to other assessments. Although several large residuals were apparent, these do not appear to have a substantial impact on estimates of current abundance (Figures 20-24). Some patterns in the residuals (by cohort and by age) suggest year class and/or year effects.

Retrospective Analysis

Retrospective analysis is used to detect a pattern of inconsistencies, where updates of previously estimated fishing mortality, biomass, and recruitment show a tendency to be systematically higher or lower. This stock assessment model, however, does not exhibit a retrospective pattern. While recruitment estimates may sometimes change substantially when more data becomes available, e.g., the 1998 and 2000 year classes, successive estimates of year class abundance at age do not display any persistent tendency to be higher or lower (Figure 25). Similarly, retrospective analysis showed no persistent patterns in the estimates of adult biomass (ages 3-8) or fishing mortality (ages 4-8 weighted by population numbers) (Figure 26).

STATE OF RESOURCE

The state of the resource was based on results from the calibrated age structured VPA. For each cohort, the terminal population abundance estimates from ADAPT were adjusted for bias estimated from the bootstrap, and used to construct the history of stock status (Tables 19-20). This approach for bias adjustment, in the absence of an unbiased point estimator with optimal statistical properties, was considered preferable to using potentially biased point estimates (O'Boyle 1998). The weights at age from the DFO survey (Table 17) were used to calculate beginning of year population biomass (Table 21). A weight of 2.4 kg, which was midway between the age 6 and 8 weight for that cohort, was used for age 7 in 1995 as no data were available for that age group. The 1986-95 average weight at each age was used for 1969-

85. Data to approximate the age composition of the catch from unit areas 5Zj and 5Zm were also available for the period between 1931 and 1955 to reconstruct an illustrative population analysis of eastern Georges Bank suitable for comparison of productivity.

Adult population biomass (ages 3+) during the late 1970s and early 1980s was about 40,000 mt, due to recruitment of the strong 1975 and 1978 year classes which were estimated to be about 50 million each (Figure 27). However, adult biomass declined rapidly in the early 1980s as subsequent recruitment was poor and these two year classes were fished intensely at young ages. Biomass steadily increased from a near record low of about 9,000 mt in 1993 to about 74,000 mt in 2003 but has since declined to about 50,000 mt (80% Confidence Interval: 40,500 mt – 63,000 mt, Figure 28, Table 21) at the beginning of 2005. The increase through the 1990s to 2003 was due to generally improved recruitment and was enhanced by lower exploitation and the reduced capture of small fish in the fisheries but two weak year classes, the 2001 and 2002, contributed to the reduction in adult biomass in 2004 and 2005. However, biomass is still near the upper range seen since 1969 and is within the range of the 1931-1955 biomass.

Recruitment improved in the 1990s and although the current estimate of 365 million age-1 fish for the 2003 year class (Table 19) is substantially lower than the estimate in the previous assessment, the 2003 year class is still estimated to be the largest in the assessment time series (1931-1955 and 1969-2004) and will increase the adult biomass by 2006 to well beyond the 1931-1955 maximum biomass of about 90,000 mt. The 2000 year class (66 million at age 1) is estimated to be larger than the strong 1975 and 1978 year classes. The 1998 year class (28 million at age 1) is the third strongest since the 1978 cohort. The 1996 and 1999 year classes are estimated to be about 17 and 13 million, respectively, comparable to the 1983, 1985 and 1987 year classes, which were the strongest 3 year classes over about a 20 year time span. Two recent year classes, 2001 and 2002, are weak, at about 4 and 2 million fish, respectively, and first estimates of the 2004 year class are also low.

Fishing mortality for fully recruited ages 4+ fluctuated between 0.2 and 0.4 during the 1980s (Figure 29) and markedly increased between 1989 and 1993 to about 0.6, the highest observed, and subsequently declined to below the fishing mortality reference, $F_{ref} = 0.26$, where it has remained since 1995 ($F_{2004} = 0.17$: 80% Confidence Interval: 0.13 – 0.21, Figure 28).

Reduced fishing mortality in recent years has resulted in increased survival of recruiting year classes. The number of haddock of the 1992 year class surviving to age 8 was about four times that of the equally abundant 1983 year class, and about the same as that of the 1975 or 1978 year classes, which were more than 3 times as abundant (Figure 30). Avoidance of small fish by the fishery has resulted in increased survivorship at age 3 of the 1998 year class in comparison to the 1978 year class which was twice as strong.

Gains in fishable biomass may be partitioned into those associated with somatic growth of haddock, which have previously recruited to the fishery, and those associated with new recruitment to the fishery (Rivard 1980). We used age 2 as the age of first recruitment to the fishery. This choice facilitated comparisons with historic stock productivity but may be less representative of the current fishery selectivity. Except for 1996 and 2003, surplus production (biomass gains from growth and from recruitment, decremented by losses due to natural deaths) since 1993 has exceeded fishery harvest yields, resulting in net population biomass increases (Figure 31). Growth of fish is the dominant component of the biomass gain but recruitment accounts for significant portions when stronger year classes enter the population (Figure 32). The biomass contributed by the recruiting 2003 year class was greater than that of any other previous cohort.

PRODUCTIVITY

Attributes like recruits per spawner, age structure and spatial distribution reflect possible fluctuations in the productive potential and can be used to qualify reference points and acceptable risk.

Stock-recruitment data indicates that the chance of a good year class is significantly enhanced for adult biomass above about 40,000 mt (Figure 35). Since 1969, only the 1975, 1978, 2000 and 2003 year classes have been above the average abundance of year classes observed during the period 1930-55. The recruits per adult biomass ratio was generally low during the 1980s but during the 1990s was comparable to that in the 1931-1955 period (Figure 34). Since 2000, two of the ratios were among the highest seen since 1931. The recruits per adult biomass ratio suggests that higher recruitment is likely to occur when the biomass is above 40,000 t.

Since 1995, a broad representation of age groups is apparent, reflecting improved recruitment and lower exploitation, particularly at younger ages (Figure 35).

Spatial distribution patterns observed during the most recent bottom trawl surveys are similar to the average patterns over the previous ten years. However, consistent with the pattern observed for previous large year classes, the exceptional 2003 year class at ages 1 and 2 as well as at age 0 was widely distributed throughout the survey area.

DFO survey average weights at length, used to reflect condition, show a decrease for smaller haddock (48 to 53 cm) during the last 2 years and a longer trend is evident for larger fish (68 to 73 cm). For these lengths, weights are at or near their lowest values in the DFO survey time series (Figure 36). The percent change in weight at length for 2002, 2003 and 2004 from the DFO survey indicate a decline in condition for most lengths during 2004. Some reduction in condition occurred during 2002 and 2003, especially for the smaller lengths but the data were more variable in these years (Figure 37).

In summary, productivity has increased since the 1980s due to improved recruits per spawner and increases in the number of larger and older fish in the population. Productivity has diminished in recent years due to reductions in average fish size at age.

PARTIAL RECRUITMENT TO THE FISHERY

The significant reduction in weights at age and the decline in condition are reflected in a reduction in partial recruitment to the fishery. The average partial recruitment for 2002 to 2004 shows a large decrease in partial recruitment for ages 3 and 4 (Figure 38). The partial recruitment values used to estimate the 2005 catch in the previous assessment (Van Eeckhaure and Brodziak 2004) were based on ages 4-8 fully recruited. This revised partial recruitment pattern will have a significant impact on estimates of the magnitude and composition of future catches.

OUTLOOK

The outlook is provided in terms of the possible consequences for alternative catch quotas in 2006 with respect to the harvest reference points. Uncertainty about standing stock

generates uncertainty in forecast results. This uncertainty is expressed in the outlook as the risk of exceeding F_{ref} = 0.26.

Stock size estimates at the beginning of 2005 were used to start the forecasts. Abundances of the 2005 and 2006 year classes were assumed to be 20 million at age 1. For each forecast, partial recruitment to the fishery for ages 1, 2, 3 and 4 and fishery weights at age were set to their averages during 2002-2004. Population weights at age were set to their observed 2005 values from the DFO survey (Table 22). It was also assumed that the eastern Georges Bank total allowable catch (TAC) of 23,000 mt was caught in 2005. Natural mortality was assumed to be 0.2.

Given these forecast assumptions, a combined Canada/USA catch of 22,000 mt in 2006 would result in a neutral risk (50%) that fishing mortality in 2006 will exceed F_{ref}=0.26. A lower catch of 18,000 mt would produce a low risk (25%) that the fishing mortality in 2006 will exceed F_{ref} (Figure 39). The 2003 year class (age 3) will comprise the highest proportion of the total 2005 yield, accounting for about half of the catch at the 22,000 mt level. The 2000 year class will account for the second highest proportion (27% of the catch biomass).

The accuracy of the risk calculations depend on model assumptions and data. Though these assumptions are judged to be reasonable, other factors not considered could generate additional uncertainty. In particular, the calculations do not include uncertainty due to variations in weight at age, partial recruitment to the fishery, natural mortality, systematic errors in data reporting, or the possibility that the model may not sufficiently reflect the dynamics of the stock. In this context, the risk profiles indicate the range of uncertainties and the consequences of alternative catch quotas.

Medium term projections were also conducted. In these forecasts (2006 to 2009), it was assumed that the stock would be exploited at a constant fishing mortality rate of 0.26 and the catch in 2005 would be 23,000 mt. Weights at age and partial recruitment were those used for the short term projection (Table 22). Recruitment was assumed to equal either the most recent 10-year average (20 million at age 1, excluding the 2003 year class) or the average recruitment which occurred during the period 1931 – 1955 average (40 million at age 1) when the stock was at a more productive level. Under either scenario, catches and biomass would be maintained at high levels through 2009 (Tables 23 and 24). Differences in projected total biomass, adult biomass and yield under the two recruitment scenarios are minimal.

SPECIAL CONSIDERATIONS

Consistent management by Canada and the USA is required to ensure that conservation objectives are not compromised.

The outstanding 2003 year class will dominate the catch during 2006 to 2009. These catches are highly dependent on the magnitude of this cohort. Measures should be taken to avoid wastage of this year class due to discarding.

Several factors have resulted in a marked decrease in the estimates of biomass and future catch levels compared to the previous assessment. The significant decrease in weights at age and condition, which are also reflected in a reduction in partial recruitment to the fishery for ages 1 to 3 (age 4 is now also only partially recruited), along with a 2 to 3 fold reduction in the current estimate of the 2003 year class are responsible for this less optimistic outlook. If the TAC in 2005 is caught, fishing mortality will be higher than F_{ref} due to the marked reduction in

weights at age and the reduced partial recruitment to the fishery of the 2003 year class at age 3 resulting in higher than predicted fishing pressure on the fully recruited older ages (F_{5+}=0.39).

Cod and haddock are often caught together in groundfish fisheries, although their catchabilities to the fisheries differ and they are not necessarily caught in proportion to their relative abundance. With current fishing practices and catch ratios, the achievement of rebuilding objectives for cod may constrain the harvesting of haddock. Additional efforts to protect the 2003 cod year class which, from first indications, is estimated to be larger than has been seen in recent years are warranted. Modifications to fishing gear and practices, with enhanced monitoring, may mitigate these concerns.

ACKNOWLEDGEMENTS

G. Donaldson, S. D'Entremont and Javitech Ltd. provided samples from the Canadian fishery. We thank members of the fishing industry who spent time to discuss their experiences in the fishery. We also thank Stacey Paul, William Overholtz and Fred Serchuk for providing valuable comments on the draft manuscript.

LITERATURE CITED

Clark, S.H., W.J. Overholtz, and R.C. Hennemuth. 1982. Review and assessment of the Georges Bank and Gulf of Maine haddock fishery. J. Northw. Atl. Fish. Sci. 3: 1-27.

DFO, 2002. Development of a sharing allocation proposal for transboundary resources of cod, haddock and yellowtail flounder on Georges Bank. DFO Maritime Provinces, Regional Fisheries Management Report 2002/01:59 p.

Efron, B., and R.J. Tibshirani. 1993. An introduction to the bootstrap. Chapman & Hall. New York. 436p.

Forrester, J.R.S., C.J. Byrne, M.J. Fogarty, M.P. Sissenwine, and E.W. Bowman. 1997. Background papers on USA vessel, trawl, and door conversion studies. SAW/SARC 24 Working Paper Gen 6. Northeast Fisheries Science Center, Woods Hole, MA.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88/29: 12 p.

Gavaris, S. 1989. Assessment of eastern Georges Bank haddock. CAFSAC Res. Doc. 89/49: 27 p.

Gavaris, S., and L. Van Eeckhaute. 1998. Assessment of haddock on eastern Georges Bank. DFO CSAS Res. Doc. 98/66: 75 p.

Gavaris, S., and L. Van Eeckhaute. 2000. Assessment of haddock on eastern Georges Bank. DFO CSAS Res. Doc. 2000/082: 68 p.

O'Boyle, R.N. (Chair.) 1998. Proceedings of the Transboundary Resource Assessment Committee 20-24 April 1998. CSAS Proc. Ser. 98/10: 49p.

Overholtz, W.J., S.H. Clark, and D.Y. White. 1983. A review of the status of the Georges Bank and Gulf of Maine haddock stocks for 1983. Woods Hole Lab. Ref. Doc. 83-23.

Rivard, D. 1980. Back-calculating production from cohort analysis, with discussion on surplus production for two redfish stocks. CAFSAC Res. Doc. 80/23: 26 p.

Schuck, H.A. 1951. Studies of Georges Bank haddock, Part I: Landings by pounds, numbers and sizes of fish. Fish. Bull. U.S., 52: 151-176.

Transboundary Management Guidance Committee, 2003. Guidance Document 2003/1, 7 p.

Van Eeckhaute, L., and J. Brodziak. 2004. Assessment of eastern Georges Bank haddock. TRAC Ref. Doc. 2004/01: 70 p.

Van Eeckhaute, L., S. Gavaris, and H. Stone. 2005. Estimation of cod, haddock and yellowtail flounder discards from the Canadian Georges Bank scallop fishery from 1960 to 2004. DFO TRAC Ref. Doc. 2005/02.

Waiwood, K.G., and J.D. Neilson. 1985. The 1985 assessment of 5Ze haddock. CAFSAC Res. Doc. 85/95:49 p.

Table 1. Nominal catches (mt) of haddock from unit areas 5Zjm during 1969-2004. For "Other" it was assumed that 40% of the total 5Z catch was in 5Zjm.

	Landings			Discards		Total	Quotas	
Year	Canada	USA	Other	Canada	USA	Catch	Canadian	USA
1969	3941	6622	695	123		11258		
1970	1970	3153	357	116		5480		
1971	1610	3534	770	111		5914		
1972	609	1551	502	133		2795		
1973	1565	1396	396	98		3455		
1974	462	955	573	160	757	2907		
1975	1353	1705	29	186		3273		
1976	1355	973	24	160		2512		
1977	2871	2429		151	2966	8417		
1978	9968	4724		177	1556	16425		
1979	5080	5211		186		10477		
1980	10017	5615		151	7561	23344		
1981	5658	9077		177		14912		
1982	4872	6280		130		11282		
1983	3208	4454		119		7781		
1984	1463	5121		124		6708		
1985	3484	1683		186		5353		
1986	3415	2200		92		5707		
1987	4703	1418		138		6259		
1988	4046	1693		151		5890		
1989	3060	787		138		3985		
1990	3340	1189		128		4657		
1991	5456	949		117		6522		
1992	4058	1629		130		5817	5000	
1993	3727	421		114		4262	5000	
1994	2411	33		114	258	2816	3000	
1995	2065	22		69	25	2181	2500	
1996	3663	36		52	41	3792	4500	
1997	2749	48		60	63	2919	3200	
1998	3371	311		102	14	3798	3900	
1999	3681	355		49		4084	3900	
2000	5402	187		29		5618	5400	
2001	6774	604		39	40	7417	6989	
2002	6488	914		29	35	7431	6740	
2003	6775	1564		98	63	8437	6933	
2004	9745	1796		93	156	11790	9900	5100

[1] 1895 mt excluded because of suspected area misreporting.

Table 2. Regulatory measures implemented for the 5Z and 5Zjm fishery management units by the USA and Canada, respectively, from 1977, when jurisdiction was extended to 200 miles for coastal states, to the present.

	USA	Canada
1977-82	Mesh size of 5 1/8" (140 mm), seasonal spawning closures, quotas and trip limits.	
1982-85	All catch controls eliminated, retained closed area and mesh size regulations, implemented minimum landings size (43 cm).	First 5Ze assessment in 1983.
1984 Oct.	Implementation of the 'Hague' line .	
1985	5 ½" mesh size, Areas 1 and 2 closed February-May.	
1989		Combined cod-haddock-pollock quota for 4X-5Zc
1990		5Zjm adopted as management unit. For MG < 65 ft. – trip limits with a 30% by-catch of haddock to a maximum of 8 trips of 35,000 lbs per trip between June 1 and Oct. 31 and 130 mm square mesh required. Fixed gear required to use large hooks until June
1991	Established overfishing definitions for haddock.	MG < 65 ft similar to 1990 but mesh size increased to 145 mm diamond.
1992		Introduction of ITQs and dockside monitoring. Total allowable catch (TAC) = 5000 mt.
1993	Area 2 closure in effect from Jan 1-June 30.	OT fishery permitted to operate in Jan. and Feb. Increase in use square mesh. TAC = 5000 mt.
1994	Jan.: Expanded Area 2 closure to include June and increased extent of area. Area 1 closure not in effect. 500 lb trip limit. Catch data obtained from mandatory log books combined with dealer reports (replaces interview system). May: 6" mesh restriction. Dec.: Area 1,2 closed year-round.	Spawning closure extended to Jan. 1 to May 31. Fixed gear vessels must choose between 5Z or 4X for the period of June to September. Small fish protocol. Increased at sea monitoring. OT > 65 could not begin fishng until July 1. Predominantly square mesh by end of year. TAC = 3000 mt.
1995		All OT vessels using square mesh. Fixed gear vessels with a history since 1990 of 25t or more for 3 years of cod, haddock pollock, hake or cusk combined can participate in 5Z fishery. ITQ vessel require at least 2t of cod and 8t of haddock quota to fish Georges. TAC = 2500 mt.
1996	July: Additional Days-at-Sea restrictions, trip limit raised to 1000 lbs.	Fixed gear history requirement dropped. TAC = 4500 mt.
1997	May: Additional scheduled Days-at-sea restrictions. September: Trip limit raised to 1000 lbs/day, maximum of 10,000 lbs/trip.	Vessels over 65 ft operated on enterprise allocations, otter trawlers under 65 ft on individual quotas, fixed gear vessels 45-65 ft on self-administered individual quotas and fixed gear vessels under 45 ft on community

	USA	Canada
		quotas administered by local boards. TAC = 3200 mt.
1998	Sept. 1: Trip limit raised to 3000 lbs/day, maximum of 30,000 lbs/trip.	Fixed gear vessels 45-65 ft operated on individual quotas. TAC = 3900 mt.
1999	May 1: Trip limit 2,000 lbs/day, max. 20,000 lbs/trip. Square mesh size increased to 6.5" (diamond is 6"). June 15: Scallop exemption fishery in Closed Area II. Nov. 5: Trip limit 5,000 lbs/day, max. 50,000 lbs/trip.	TAC = 3,900 mt.
2000	October: Daily trip limit suspended to April 2001but retained max. trip limit of 50,000 lbs/trip.	TAC = 5,400 mt.
2001-2002	Day and trip limit adjustments. Daily trip limit suspended July 5, 2002.	TAC = 6,989 m. and 6,740 mt for 2001 and 2002 respectively.
2002-2003	30,000 – 50,000 lb/trip limit. Trip limit suspended in Oct. 2003.	TAC = 6,933 mt for 2003.
2004	May 1, day and trip limits removed. TAC = 5,100 mt. Oct. 1: 5Zjm closed to groundfish vessels. Nov. 19: Special Access Program (SAP) for haddock opened. Dec. 31: Haddock SAP closed.	TAC = 9,900 mt.
2005	TAC= 7,590 mt. Jan. 14: Haddock separator trawl required.	TAC = 15,410 mt

Table 3. Canadian landings (mt) of haddock in unit areas 5Zjm during 1969-2004 by gear category and tonnage class for principle gears.

Year	Otter Trawl						Longline			Scallop Fishery	Other	Total
	Side	Stern										
		2	3	4	5	Total[1]	2	3	Total[1]			
1969	777	0	1	225	2902	3127	2	21	23	15	0	3941
1970	575	2	0	133	1179	1314	6	72	78	2	1	1970
1971	501	0	0	16	939	955	18	129	151	3	0	1610
1972	148	0	0	2	260	263	23	169	195	1	2	609
1973	633	0	0	60	766	826	23	80	105	0	1	1565
1974	27	0	6	8	332	346	29	59	88	1	0	462
1975	222	0	1	60	963	1024	25	81	107	0	0	1353
1976	217	0	2	59	905	967	48	108	156	0	15	1355
1977	370	92	243	18	2025	2378	43	51	94	1	28	2871
1978	2456	237	812	351	5639	7039	121	47	169	17	287	9968
1979	1622	136	858	627	1564	3185	190	80	271	2	0	5080
1980	1444	354	359	950	6254	7917	129	51	587	4	65	10017
1981	478	448	629	737	2344	4159	331	99	1019	1	1	5658
1982	115	189	318	187	3341	4045	497	187	712	0	0	4872
1983	106	615	431	107	1130	2283	593	195	815	1	3	3208
1984	5	180	269	21	149	620	614	192	835	2	1	1463
1985	72	840	1401	155	348	2745	562	33	626	2	39	3484
1986	51	829	1378	95	432	2734	475	98	594	4	32	3415
1987	48	782	1448	49	1241	3521	854	113	1046	38	50	4703
1988[2]	72	1091	1456	186	398	3183	428	200	695	16	80	4046
1989	0	489	573	376	536	1976	713	175	977	12	95	3060
1990	0	928	890	116	471	2411	623	173	853	7	69	3340
1991	0	1610	1647	81	689	4028	900	271	1309	8	111	5456
1992	0	797	1084	56	645	2583	984	245	1384	4	87	4058
1993	0	535	1179	67	699	2489	794	156	1143	2	93	3727
1994	0	495	911	79	112	1597	498	47	714	9	91	2411
1995	0	523	896	14	214	1647	256	75	390	7	21	2065
1996	1	836	1405	166	270	2689	561	107	947	0	26	3663
1997	0	680	1123	91	96	1991	501	116	722	0	36	2749
1998	0	863	1340	98	71	2422	570	252	921	0	28	3371
1999	0	954	1471	174	145	2761	486	241	887	0	32	3680
2000	0	1313	2269	230	246	4146	619	258	1186	0	70	5402
2001	0	1564	2555	0	757	5112	754	302	1633	0	29	6774
2002	0	1217	2720	0	657	4954	794	151	1521	0	12	6488
2003	0	1186	3246	0	0	4985	806	249	1776	0	14	6775
2004	0	2152	4651	0	67	7744	716	223	2000	0	1	9745

[1] Total includes catches for tonnage classes which are not listed, only tonnage classes with substantial catches listed

[2] Catches of 26t, 776t, 1091t and 2t for side otter trawlers and stern otter trawlers tonnage classes 2, 3 and 5 respectively were excluded because of suspected area misreporting.

Table 4. Monthly landings (mt) of haddock by Canada in unit areas 5Zjm during 1969-2004.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	105	74	6	291	588	691	559	580	551	360	102	34	3941
1970	2	105	0	1	574	345	103	456	242	103	26	12	1970
1971	0	9	1	0	400	132	283	278	97	246	141	21	1610
1972	0	119	2	0	2	111	84	116	98	68	7	2	609
1973	4	10	0	0	0	184	198	572	339	232	22	4	1565
1974	19	0	1	0	0	58	63	53	96	61	92	19	462
1975	4	14	0	0	0	166	256	482	100	166	118	45	1353
1976	0	7	62	68	60	587	152	190	186	26	9	7	1355
1977	102	177	7	0	23	519	1059	835	13	59	56	22	2871
1978	104	932	44	22	21	319	405	85	642	5433	1962	0	9968
1979	123	898	400	175	69	1393	885	396	406	261	53	22	5080
1980	38	134	14	29	223	2956	2300	965	1411	1668	104	176	10017
1981	38	481	568	4	254	1357	1241	726	292	82	378	239	5658
1982	129	309	1	11	46	1060	769	682	585	837	398	44	4872
1983	32	67	29	47	60	1288	387	483	526	195	88	6	3208
1984	3	5	81	88	73	433	219	254	211	71	25	0	1463
1985	1	11	33	99	26	354	392	1103	718	594	61	93	3484
1986	11	28	79	99	40	1339	1059	369	233	139	12	8	3415
1987	24	26	138	70	12	1762	1383	665	405	107	97	14	4703
1988[1]	39	123	67	79	15	1816	1360	315	130	65	13	24	4046
1989	33	94	48	7	20	1398	356	566	141	272	108	18	3060
1990	35	14	50	0	7	1178	668	678	469	199	18	22	3340
1991	144	166	49	26	21	1938	1004	705	566	576	123	137	5456
1992	118	205	97	152	36	1381	619	414	398	401	209	28	4058
1993	468	690	96	78	25	723	505	329	202	198	230	183	3727
1994	3	3	1	2	0	398	693	373	375	220	211	133	2411
1995	5	1	1	1	0	762	327	290	281	109	197	93	2065
1996	0	0	0	0	0	1067	672	706	359	278	191	391	3663
1997	0	0	0	0	0	328	751	772	426	190	116	166	2749
1998	0	0	0	0	0	687	420	580	707	542	164	271	3371
1999	37	0	0	0	0	898	975	562	573	295	269	70	3681
2000	1	0	0	0	0	1368	1175	1026	848	658	175	150	5402
2001	0	0	0	0	0	971	1335	930	1267	1075	647	548	6774
2002	0	0	0	0	0	572	1703	983	1364	820	593	452	6488
2003	0	0	0	0	0	840	1767	1290	930	952	676	320	6775
2004	0	0	0	0	0	1547	2268	2109	1753	1275	556	236	9745

[1] Catches of 3t, 1846t and 46t for Jan., Feb., and Mar., respectively for otter trawlers were excluded because of suspected area misreporting

Table 5. USA landings (mt) of haddock in unit areas 5Zjm during 1969-2004 by gear category and tonnage class. Details for 1994-2004 are not available because data are preliminary.

Year	Otter Trawl			Other	Total
	3	4	Total		
1969	3010	3610	6621	0	6622
1970	1602	1551	3154	0	3153
1971	1760	1768	3533	0	3534
1972	861	690	1551	0	1551
1973	637	759	1396	0	1396
1974	443	512	955	0	955
1975	993	675	1668	36	1705
1976	671	302	972	2	973
1977	1721	700	2423	5	2429
1978	3140	1573	4713	11	4724
1979	3281	1927	5208	4	5211
1980	3654	2955	5611	4	5615
1981	3591	5408	9031	45	9077
1982	2585	3657	6242	37	6280
1983	1162	3261	4423	29	4454
1984	1854	3260	5115	5	5121
1985	856	823	1679	4	1683
1986	985	1207	2192	9	2200
1987	778	639	1417	1	1418
1988	920	768	1688	6	1693
1989	359	419	780	6	787
1990	486	688	1178	4	1189
1991	400	517	918	13	931
1992	597	740	1337	292	1629
1993	142	191	333	88	421
1994			32	0	33
1995			21	0	22
1996			36	0	36
1997			48	0	48
1998			311	0	311
1999			355	0	355
2000			187	0	187
2001			602	2	604
2002			913	1	914
2003			1564	0	1564
2004			1794	2	1796

Table 6. Monthly landings (mt) of haddock by USA in unit areas 5Zjm during 1969-2004. Details for 1994-2004 are not available because data are preliminary.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1969	525	559	976	1825	670	809	204	219	249	226	203	157	6622
1970	169	219	242	375	608	374	324	333	179	219	61	50	3153
1971	155	361	436	483	668	503	338	152	147	165	58	68	3534
1972	150	196	91	90	239	261	97	164	84	63	52	64	1551
1973	90	111	77	85	138	365	217	196	37	3	22	55	1396
1974	135	70	47	70	122	160	165	43	27	6	19	91	955
1975	152	123	32	116	388	489	138	95	57	24	52	39	1705
1976	116	147	83	106	323	162	7	6	5	2	3	13	973
1977	75	211	121	154	374	372	434	191	73	52	146	226	2429
1978	336	437	263	584	752	750	467	221	245	426	194	49	4724
1979	274	329	352	548	766	816	588	659	224	202	281	172	5211
1980	632	1063	742	784	711	461	324	254	221	91	110	222	5615
1981	550	1850	634	627	882	1326	1233	873	321	284	242	255	9077
1982	425	754	502	347	718	1801	757	145	201	216	276	138	6280
1983	492	931	272	181	310	1145	231	178	187	110	227	190	4454
1984	540	961	366	281	627	1047	370	302	250	196	92	89	5121
1985	165	190	254	300	352	206	60	47	1	24	41	43	1683
1986	184	396	334	479	496	221	31	6	12	6	6	29	2200
1987	225	52	43	307	233	342	67	30	24	4	23	68	1418
1988	196	152	207	245	366	316	30	19	6	1	45	110	1693
1989	114	56	47	164	161	145	15	8	1	5	25	46	787
1990	148	21	155	274	214	306	23	3	5	5	16	19	1189
1991	105	28	76	133	89	434	1	20	6	0	19	19	931
1992	253	81	51	149	353	669	20	20	17	3	2	12	1629
1993	15	12	16	55	84	209	6	3	3	7	2	8	421
1994													33
1995													22
1996													36
1997													48
1998													311
1999													355
2000													187
2001													604
2002													914
2003													1564
2004													1796

Table 7. USA landings of haddock in 2004 by quarter and market category from unit areas 5Zjm and NMFS sampling intensity for lengths and ages.

Market Category	Large	Scrod	Unclassified	Total
		Landings (mt)		
Quarter 1	70.59	192.95	2.62	266.16
Quarter 2	233.12	959.89	2.92	1195.93
Quarter 3	64.53	238.02	6.46	309.01
Quarter 4	4.04	20.63		24.67
Total	372.28	1411.48	12.01	1795.77
		Length per 100 mt (Number measured)		
Quarter 1	147.33 (104)	0.00 (0)	N/A	147.33 (104)
Quarter 2	137.70 (321)	36.67 (352)	N/A	174.37 (673)
Quarter 3	339.38 (219)	97.47 (232)	N/A	436.85 (451)
Quarter 4	0.00 (0)	0.00 (0)	N/A	0.00 (0)
Total	624.40 (644)	166.57 (584)	N/A	758.55 (1228)
		Age per 100 mt (Number aged)		
Quarter 1	35.42 (25)	0.00 (0)	N/A	35.42 (25)
Quarter 2	32.60 (76)	8.86 (85)	N/A	41.46 (161)
Quarter 3	58.89 (38)	27.31 (65)	N/A	86.20 (103)
Quarter 4	0.00 (0)	0.00 (0)	N/A	0.00 (0)
Total	126.90 (139)	36.16 (150)	N/A	163.07 (289)

Table 8. Sampling for landings of the 2004 5Zjm Canadian haddock fishery.

Qtr.	Gear	Month	Landings (kg)	Length Frequency Samples				Ages	
				At Sea		Port			
				Trips	Measured	Samples	Measured	At Sea	Port
2	OT <65	June	1,467,485	21	14,481	8	1,967		
	OT >65	June	67,357	1	790			97	226
	LL <65	June	11,828	1	13	1	280		
	GN <65	June	53						
3	OT <65	July	1,901,181	11	6,333	7	1,780		
		Aug	1,516,468	8	3,364	7	1,712		
		Sept	1,218,361	6	2,585	1	235		
	LL <65	July	366,823	6	4,838	5	1,294		
		Aug	592,279	6	4,712	5	1,220		
		Sept	534,753	3	3,579	5	1,216	40	432
	GN <65	July	137						
		Aug	312						
		Sept	181						
	HL <65	Aug	6						
	DR		11,795	2	315				
4	OT <65	Oct	986,377	8	3,527	5	1,247		
		Nov	394,094	3	1,118	5	1,108		
		Dec	192,326	8	5,062	2	481		
	LL <65	Oct	288,557	7	6,240	3	740	39	344
		Nov	161,570	3	2,500	4	1,028		
		Dec	44,112	3	3,588				
	GN <65	Nov	435						
	DR		45,497	3	760				
Totals			9,801,987	95	63,805	58	14,308	176	1,002

OT=Otter Trawl Bottom, GN=Gill Net, LL=Longline, DR=Scallop Dredge, <65=Less than 65' overall length, >65=Greater than 65' overall length

Table 9. Annual Canadian scallop fishery numbers of discards at age of haddock from unit areas 5Zjm during 1968-2004.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	0+
1968	447	926	19570	497	3021	37589	12655	2402	854	3131	81093
1969	5100	75	151	9940	1908	2691	24549	11764	2008	3197	61383
1970	0	37835	2452	93	3945	4738	4095	14080	9209	3290	79737
1971	38910	0	18838	4292	0	5498	1516	1716	18712	5696	95178
1972	106447	84526	0	14347	1563	300	1747	2505	315	20588	232338
1973	6043	96156	38054	0	6345	823	0	1517	0	6540	155477
1974	8228	19472	157619	30068	0	2129	0	219	370	5441	223546
1975	500371	16564	9201	81183	15248	0	2318	1350	483	2675	629392
1976	996	328886	8629	8511	23215	10755	0	24	0	484	381499
1977	140	1286	196560	2520	4497	3939	2820	11	109	460	212341
1978	99299	3709	6284	127822	2706	3473	4849	323	85	420	248968
1979	10936	202565	2397	9136	61083	2785	454	2321	218	45	291939
1980	27604	28250	146056	1681	2433	17128	1766	760	1081	546	227304
1981	5554	50808	30785	89891	7725	3053	8786	823	133	186	197744
1982	515	2121	19038	9887	49173	4056	2458	6915	237	109	94508
1983	67551	9975	9806	14173	7925	25630	533	224	7194	403	143415
1984	691	66959	22811	10774	9246	6532	12208	916	508	4004	134650
1985	253450	8175	83115	11795	5151	9616	4177	11555	695	3087	390816
1986	232	72307	1911	28958	2683	1115	1798	1179	1846	1170	113200
1987	27201	495	73884	4662	22423	4402	2109	1482	1488	3336	141483
1988	1237	43732	2156	61174	2837	16747	2667	2606	788	2145	136089
1989	2952	1954	95290	7712	23918	3072	6191	366	479	1060	142994
1990	20785	21954	917	62818	2468	12096	1065	2512	219	593	125427
1991	31290	16805	19587	3402	37453	1688	3983	325	1008	421	115963
1992	136917	48386	18766	9036	1091	19365	143	4507	975	1892	241079
1993	4602	73235	39608	7914	3575	1815	10904	716	1704	1025	145096
1994	15107	30831	67003	25773	4243	1965	360	3318	113	1004	149718
1995	2465	6418	22858	22038	6942	1204	627	58	1287	1211	65109
1996	6509	3631	5119	15612	10544	4726	442	254	31	965	47833
1997	860	26318	17061	4484	7185	5561	2318	231	197	522	64739
1998	15542	20134	37899	12031	7589	8008	8330	1713	269	537	112052
1999	1770	25932	8388	13969	3534	4059	2487	2450	1090	382	64061
2000	1271	6049	9290	5607	3253	902	514	753	387	263	28289
2001	445	23819	2700	11421	4087	3317	996	663	784	870	49103
2002	47	668	23319	4386	4098	1177	740	276	201	446	35359
2003	611212	664	1626	37304	4188	7414	1166	981	313	1098	665967
2004	3030	177895	1347	1839	37471	2729	5411	940	848	413	231922

Table 10. Components of the 2004 catch at age in numbers of haddock from unit areas 5Zjm by quarter.

	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
Canada											
2004	0	0	0	0	0	0	0	0	0	0	0
2004.25	0	120	417	2774	329694	92199	286731	92327	68224	40685	913172
2004.5	0	0	585	21491	1971794	224980	711895	248427	217308	114706	3511187
2004.75	0	0	446	10743	847013	90429	212430	58922	36027	29039	1285049
Year total	0	120	1449	35008	3148501	407608	1211056	399676	321560	184431	5709408
USA											
2004	0	0	0	100	2500	92900	16800	27600	7800	7300	155100
2004.25	0	0	0	300	233300	48700	188900	64000	72500	57400	665200
2004.5	0	0	0	900	95400	9300	38000	12100	13700	9100	178500
2004.75	0	0	0	0	9100	1100	2900	800	600	500	15200
Year total	0	0	0	1300	340300	152000	246600	104500	94600	74300	1014000
Canadian Discards											
2004	0	30700	563	570	10783	915	1601	280	235	158	45805
2004.25	0	24182	444	449	8494	720	1261	220	185	124	36080
2004.5	624	25326	70	169	3746	225	525	91	88	27	30890
2004.75	2406	97686	270	651	14448	869	2024	349	340	104	119148
Year total	3030	177895	1347	1839	37471	2729	5411	940	848	413	231922
USA Discards											
2004	0	584	1533	597	945	7511	1057	941	210	71	13449
2004.25	0	87397	12714	10515	65897	14665	15649	5171	583	411	213001
2004.5	2179	76556	717	13172	1068	2560	655	617	113	251	97888
2004.75	0	1064	23	199	14	18	6	6	0	8	1338
Year total	2179	165602	14987	24484	67923	24754	17366	6734	906	741	325676
Total											
2004	0	31285	2096	1267	14228	101326	19458	28820	8245	7529	214354
2004.25	0	111700	13574	14038	637384	156284	492541	161719	141493	98621	1827452
2004.5	2803	101882	1373	35732	2072007	237065	751074	261235	231210	124084	3818465
2004.75	2406	98750	740	11594	870575	92415	217359	60077	36967	29651	1420735
Year total	5209	343616	17783	62631	3594194	587090	1480432	511851	417915	259885	7281006

Table 11. Total annual commercial catch at age numbers (000's) of haddock from unit areas 5Zjm during 1969-2004. Estimates of discards are included.

Year	Age Group										
	0	1	2	3	4	5	6	7	8	9+	1+
1969	5	0	18	1451	262	334	2909	831	91	283	6184
1970	0	63	84	7	351	151	130	1154	373	193	2505
1971	7	94	1198	250	32	248	158	160	769	410	3325
1972	106	343	1	390	72	21	94	40	16	452	1535
1973	6	1112	1760	6	364	38	10	39	8	170	3513
1974	8	36	2263	277	0	33	3	0	29	62	2711
1975	500	17	279	1509	216	5	36	2	3	31	2598
1976	1	402	158	174	837	136	0	19	0	18	1744
1977	0	1	8032	66	182	307	164	0	15	15	8783
1978	99	5	291	9958	164	173	307	80	10	9	11097
1979	11	203	18	208	4312	365	201	217	43	14	5592
1980	28	31	17707	343	302	2425	193	130	52	12	21222
1981	6	51	691	6777	400	497	1243	119	33	7	9825
1982	1	2	732	1058	2848	205	380	730	62	65	6082
1983	68	10	149	662	554	1655	208	104	409	35	3854
1984	1	67	99	260	351	271	1132	187	166	318	2850
1985	253	8	2146	386	181	199	127	382	53	117	3853
1986	0	78	40	2586	176	143	124	119	175	42	3482
1987	27	0	2064	131	1537	101	58	83	70	112	4184
1988	1	48	53	2206	123	894	112	39	46	100	3623
1989	3	2	1248	85	758	132	326	31	21	46	2653
1990	21	24	8	1327	128	755	69	166	42	42	2582
1991	31	22	461	93	2078	90	393	73	146	61	3448
1992	137	55	249	320	128	1465	89	320	27	92	2881
1993	5	80	286	351	283	87	646	34	155	75	2001
1994	15	32	308	763	152	56	49	129	29	40	1573
1995	2	8	83	547	421	54	26	3	52	17	1214
1996	7	4	34	497	872	424	61	18	3	73	1994
1997	1	29	98	85	549	488	196	13	8	34	1502
1998	16	21	201	294	266	547	454	116	12	35	1963
1999	2	27	44	751	319	248	346	255	99	25	2116
2000	1	6	318	443	1249	249	201	209	182	65	2924
2001	0	27	67	1720	525	831	255	199	226	194	4046
2002	0	1	357	222	1862	370	657	110	106	278	3963
2003	611	5	9	1805	281	1460	419	470	107	227	5394
2004	5	344	18	63	3594	587	1480	512	418	260	7281

Table 12. Average weight at age (kg) of haddock from the Canadian commercial fishery in unit areas 5Zjm during 1969-2004. The 1989 to 1991 year-classes (shaded) grew faster than adjacent year-classes.

Year	Age Group							
	1	2	3	4	5	6	7	8
1969	0.600	0.763	1.282	1.531	1.649	1.836	2.298	2.879
1970	0.721	1.067	0.812	1.653	1.886	2.124	2.199	2.841
1971	0.600	0.928	1.059	1.272	2.011	2.255	2.262	2.613
1972	0.759	1.000	1.562	1.750	2.147	2.505	2.411	2.514
1973	0.683	1.002	1.367	1.804	2.202	1.631	2.885	3.295
1974	0.600	0.970	1.418	1.800	1.984	3.760	2.700	3.128
1975	0.600	0.872	1.524	2.062	1.997	2.422	4.114	3.557
1976	0.596	0.956	1.293	1.857	2.417	2.700	2.702	3.000
1977	0.600	0.970	1.442	1.809	2.337	2.809	2.700	3.095
1978	0.619	1.151	1.433	2.055	2.623	2.919	2.972	2.829
1979	0.600	0.987	1.298	1.805	2.206	2.806	3.219	3.277
1980	0.405	0.892	1.034	1.705	2.115	2.593	3.535	3.608
1981	0.600	0.890	1.262	1.592	2.270	2.611	3.505	4.009
1982	0.600	0.965	1.363	1.786	2.327	2.557	2.958	3.531
1983	0.600	1.024	1.341	1.750	2.118	2.509	2.879	3.104
1984	0.600	0.876	1.354	1.838	2.159	2.605	2.856	3.134
1985	0.600	0.950	1.230	1.915	2.227	2.702	2.872	3.180
1986	0.452	0.981	1.352	1.866	2.367	2.712	2.969	3.570
1987	0.600	0.833	1.431	1.984	2.148	2.594	2.953	3.646
1988	0.421	0.974	1.305	1.708	2.042	2.350	3.011	3.305
1989	0.600	0.868	1.450	1.777	2.183	2.522	3.012	3.411
1990	0.639	0.999	1.419	1.787	2.141	2.509	2.807	3.002
1991	0.581	1.197	1.241	1.802	2.087	2.596	2.918	3.012
1992	0.538	1.163	1.622	1.654	2.171	2.491	2.988	3.388
1993	0.659	1.160	1.724	2.181	2.047	2.623	2.386	3.112
1994	0.405	1.135	1.661	2.235	2.639	2.422	2.831	3.223
1995	0.797	1.055	1.511	2.033	2.550	2.755	2.908	3.010
1996	0.576	1.022	1.439	1.795	2.294	2.485	3.322	2.032
1997	0.685	1.215	1.336	1.747	2.120	2.476	3.034	3.365
1998	0.568	1.131	1.573	1.697	1.983	2.312	2.864	3.395
1999	0.678	1.095	1.570	1.910	1.865	2.182	2.535	2.773
2000	0.664	1.103	1.470	1.920	2.242	2.098	2.497	2.816
2001	0.394	1.102	1.471	1.755	2.107	2.367	2.186	2.522
2002	0.405	1.009	1.417	1.762	1.940	2.339	2.657	2.377
2003	0.475	0.758	1.381	1.589	1.851	1.894	2.343	2.839
2004	0.482	0.589	1.102	1.514	1.643	1.880	2.002	2.282
Low	0.394	0.589	0.812	1.272	1.643	1.631	2.002	2.032
High	0.797	1.215	1.724	2.235	2.639	3.760	4.114	4.009
Median	0.600	0.993	1.399	1.791	2.144	2.507	2.868	3.108
Average	0.583	0.990	1.376	1.797	2.142	2.471	2.814	3.074
2000-04	0.484	0.912	1.368	1.708	1.957	2.116	2.337	2.567

Table 13. Conversion factors used to adjust for changes in door type and survey vessel in the NMFS surveys during 1968-2005.

Year	Door	Spring		Fall	
		Vessel	Conversion	Vessel	Conversion
1968	BMV	Albatross IV	1.49	Albatross IV	1.49
1969	BMV	Albatross IV	1.49	Albatross IV	1.49
1970	BMV	Albatross IV	1.49	Albatross IV	1.49
1971	BMV	Albatross IV	1.49	Albatross IV	1.49
1972	BMV	Albatross IV	1.49	Albatross IV	1.49
1973	BMV	Albatross IV	1.49	Albatross IV	1.49
1974	BMV	Albatross IV	1.49	Albatross IV	1.49
1975	BMV	Albatross IV	1.49	Albatross IV	1.49
1976	BMV	Albatross IV	1.49	Albatross IV	1.49
1977	BMV	Albatross IV	1.49	Delaware II	1.2218
1978	BMV	Albatross IV	1.49	Delaware II	1.2218
1979	BMV	Albatross IV	1.49	Delaware II	1.2218
1980	BMV	Albatross IV	1.49	Delaware II	1.2218
1981	BMV	Delaware II	1.2218	Delaware II	1.2218
1982	BMV	Delaware II	1.2218	Albatross IV	1.49
1983	BMV	Albatross IV	1.49	Albatross IV	1.49
1984	BMV	Albatross IV	1.49	Albatross IV	1.49
1985	Polyvalent	Albatross IV	1	Albatross IV	1
1986	Polyvalent	Albatross IV	1	Albatross IV	1
1987	Polyvalent	Albatross IV	1	Albatross IV	1
1988	Polyvalent	Albatross IV	1	Albatross IV	1
1989	Polyvalent	Delaware II	0.82	Delaware II	0.82
1990	Polyvalent	Delaware II	0.82	Delaware II	0.82
1991	Polyvalent	Delaware II	0.82	Delaware II	0.82
1992	Polyvalent	Albatross IV	1	Albatross IV	1
1993	Polyvalent	Albatross IV	1	Delaware II	0.82
1994	Polyvalent	Delaware II	0.82	Albatross IV	1
1995	Polyvalent	Albatross IV	1	Albatross IV	1
1996	Polyvalent	Albatross IV	1	Albatross IV	1
1997	Polyvalent	Albatross IV	1	Albatross IV	1
1998	Polyvalent	Albatross IV	1	Albatross IV	1
1999	Polyvalent	Albatross IV	1	Albatross IV	1
2000	Polyvalent	Albatross IV	1	Albatross IV	1
2001	Polyvalent	Albatross IV	1	Albatross IV	1
2002	Polyvalent	Albatross IV	1	Albatross IV	1
2003	Polyvalent	Delaware II	0.82	Delaware II	0.82
2004	Polyvalent	Albatross IV	1	Albatross IV	1
2005	Polyvalent	Albatross IV	1		

Table 14. Total swept area estimates of abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from DFO surveys during 1986-2005.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1986	5057	306	8176	997	189	348	305	425	401	16205
1987	46	4286	929	3450	653	81	387	135	1132	11099
1988	971	49	12714	257	4345	274	244	130	686	19670
1989	48	6664	991	2910	245	526	40	34	265	11724
1990	726	108	12300	168	4466	299	1370	144	389	19968
1991	383	2163	134	10819	114	1909	117	505	225	16368
1992	1914	3879	1423	221	4810	18	1277	52	656	14249
1993	3448	1759	545	431	34	1186	19	281	147	7849
1994	4197	15163	5332	549	314	20	915	18	356	26864
1995	1231	3224	6236	3034	720	398	0	729	849	16422
1996	1455	2290	4784	5305	3113	303	274	38	684	18247
1997	1033	1550	1222	2742	2559	1397	150	65	372	11090
1998	2379	10626	5348	3190	5312	5028	2248	348	601	35080
1999	24593	4787	10067	3104	1963	1880	1764	448	174	48780
2000	3177	15865	7679	12108	2900	2074	2726	1591	813	48932
2001	23026	3519	14633	4255	5608	1808	1426	1963	2299	58536
2002	732	28174	5977	12659	2980	2644	647	528	2420	56760
2003	1682	1503	82161	5533	15105	3675	2355	1106	1986	115107
2004	91843	539	2682	54882	5001	9695	1654	954	634	167883
2005	1669	20958	531	1557	25559	3403	4815	1087	548	60125

Table 15. Total swept area estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from NMFS spring surveys during 1968-2005. From 1973-81, a 41 Yankee trawl was used while a 36 Yankee trawl was used in other years. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	1	2	3	4	5	6	7	8	9+	Total
1968	0	3254	68	679	4853	2045	240	123	234	11496
1969	17	35	614	235	523	3232	1220	358	489	6724
1970	478	190	0	560	998	441	3165	2491	769	9092
1971	0	655	261	0	144	102	58	1159	271	2650
1972	2594	0	771	132	25	47	211	27	1214	5020
1973	2455	5639	0	1032	154	0	276	0	1208	10763
1974	1323	20596	4084	0	354	0	43	72	322	26795
1975	528	567	6016	1063	0	218	127	45	208	8773
1976	8228	402	424	1127	532	0	0	0	22	10735
1977	126	26003	262	912	732	568	0	22	102	28727
1978	0	743	20859	641	880	1163	89	23	116	24516
1979	10496	441	1313	9764	475	72	445	42	9	23056
1980	4355	66450	1108	1086	5761	613	371	693	360	80797
1981	3281	2823	27085	2906	751	2455	347	56	21	39725
1982	584	3703	1658	7802	767	455	697	0	0	15666
1983	238	770	686	359	2591	30	0	798	58	5529
1984	1366	1414	1046	910	847	1189	133	73	490	7469
1985	40	8911	1396	674	1496	588	1995	127	483	15709
1986	3334	280	3597	246	210	333	235	560	159	8953
1987	122	5480	144	1394	157	231	116	370	0	8013
1988	305	61	1868	235	611	203	218	178	0	3678
1989	84	6665	619	1343	267	791	58	92	47	9966
1990	1654	70	10338	598	1042	110	182	0	0	13995
1991	740	2071	432	3381	192	203	66	87	25	7198
1992	529	287	205	158	602	32	46	46	0	1905
1993	1870	1116	197	232	195	717	77	35	43	4480
1994	1025	4272	1487	269	184	118	278	28	84	7745
1995	921	2312	4184	1727	265	152	51	272	214	10099
1996	912	1365	3789	3190	1905	237	36	0	496	11931
1997	1635	1226	380	595	470	343	24	44	20	4736
1998	549	6046	2005	1281	1184	303	58	15	122	11562
1999	6286	1914	3655	661	1128	1062	468	476	46	15696
2000	2675	2131	3399	1624	636	564	438	305	165	11938
2001	10503	1186	3304	1232	374	294	113	20	20	17047
2002	231	40432	10938	4044	1492	473	287	229	236	58362
2003	125	1105	16915	2245	3773	476	200	82	286	25206
2004	195013	4724	2644	45872	3544	5261	960	1245	842	260104
2005	540	32911	257	614	5818	671	1196	240	67	42313

Table 16. Total swept area estimated abundance at age (numbers in 000's) of haddock for unit areas 5Zjm from NMFS fall surveys during 1963-2004. Conversion factors to adjust for changes in door type and survey vessel were applied.

Year	Age Group									
	0	1	2	3	4	5	6	7	8+	Total
1963	105993	40995	10314	3378	5040	4136	1477	451	276	172061
1964	1178	123976	46705	4358	807	1865	477	211	167	179742
1965	259	1503	51338	8538	479	302	142	148	208	62918
1966	9325	751	1742	20323	3631	671	138	133	84	36798
1967	0	3998	73	327	1844	675	141	88	88	7233
1968	55	113	800	28	37	2223	547	177	313	4293
1969	356	0	0	509	62	30	739	453	108	2257
1970	0	6400	336	16	415	337	500	902	578	9483
1971	2626	0	788	97	0	265	27	73	594	4471
1972	4747	2396	0	232	0	0	53	0	275	7702
1973	1223	16797	1598	0	168	0	0	8	16	19809
1974	151	234	961	169	0	6	0	0	70	1589
1975	30365	664	192	1042	239	0	0	0	28	32530
1976	738	121717	431	25	484	71	0	17	37	123521
1977	47	238	26323	445	125	211	84	4	4	27480
1978	14642	547	530	7706	56	42	94	0	0	23617
1979	1598	21605	14	335	1489	45	12	0	0	25098
1980	3556	2788	5829	0	101	1081	108	25	4	13492
1981	596	4617	2585	2748	89	136	318	0	15	11103
1982	62	0	673	465	2508	153	97	528	42	4527
1983	3609	444	236	501	289	402	17	12	86	5598
1984	45	3775	856	233	194	45	262	0	41	5451
1985	12148	381	1646	199	70	68	46	30	21	14611
1986	30	7471	109	961	52	50	72	24	23	8793
1987	508	0	843	28	152	38	22	0	0	1592
1988	122	3983	184	2348	155	400	142	140	38	7513
1989	167	83	2645	112	509	68	73	0	0	3656
1990	1217	1041	36	1456	65	196	24	5	0	4040
1991	705	331	267	52	289	25	10	0	0	1679
1992	3484	1052	172	110	0	95	0	18	18	4948
1993	652	6656	3601	585	0	87	96	30	0	11707
1994	625	782	927	419	96	32	0	24	0	2905
1995	892	1436	5993	3683	550	30	0	0	53	12637
1996	1742	453	570	2302	963	167	0	0	0	6196
1997	217	5738	3368	592	690	385	0	0	13	11004
1998	2566	2966	4214	1085	705	526	722	0	0	12784
1999	3268	1236	5364	5060	837	2825	148	1150	991	20879
2000	1368	5284	6226	3712	622	229	0	146	97	17684
2001	659	16626	1382	6939	3000	1586	306	127	58	30684
2002	172	1864	44602	6040	5120	1660	863	457	354	61131
2003	196182	60	285	3415	655	739	20	99	158	201613
2004	2864	116289	322	775	17200	1034	2410	416	528	141837

Table 17. Average weight at age (kg) from DFO surveys during 1986-2005, which are used to represent beginning of year weights.

Year	Age Group								
	1	2	3	4	5	6	7	8	9+
1986	0.135	0.451	0.974	1.445	3.044	2.848	3.598	3.376	3.918
1987	0.150	0.500	0.716	1.672	2.012	2.550	3.148	3.151	3.629
1988	0.097	0.465	0.931	1.795	1.816	1.918	2.724	3.264	3.871
1989	0.062	0.474	0.650	1.392	1.995	2.527	2.158	2.859	3.141
1990	0.149	0.525	0.924	1.181	1.862	2.073	2.507	2.815	3.472
1991	0.120	0.685	0.800	1.512	1.695	2.434	2.105	3.122	3.432
1992	0.122	0.602	1.118	1.061	2.078	2.165	2.709	2.284	3.440
1993	0.122	0.481	1.227	1.803	1.274	2.332	2.343	2.739	3.280
1994	0.107	0.469	1.047	1.621	1.927	2.154	3.154	2.688	3.084
1995	0.086	0.493	0.963	1.556	2.222	2.445		2.991	3.184
1996	0.139	0.495	0.919	1.320	1.932	2.555	2.902	2.611	3.588
1997	0.132	0.506	0.782	1.205	1.664	2.176	2.454	2.577	3.158
1998	0.107	0.535	1.035	1.161	1.570	1.954	2.609	3.559	3.462
1999	0.130	0.474	0.911	1.290	1.259	1.869	2.131	2.722	2.992
2000	0.116	0.543	0.949	1.478	1.871	1.789	2.298	2.508	2.901
2001	0.093	0.524	1.005	1.371	1.798	2.165	2.250	2.593	2.928
2002	0.096	0.332	0.778	1.138	1.494	1.965	2.177	2.206	2.708
2003	0.080	0.369	0.846	1.063	1.477	1.645	2.208	2.229	2.487
2004	0.064	0.310	0.781	1.151	1.306	1.558	1.622	1.956	2.216
2005	0.028	0.218	0.493	0.696	1.226	1.321	1.531	1.600	2.444
Low	0.028	0.218	0.493	0.696	1.226	1.321	1.531	1.600	2.216
High	0.150	0.685	1.227	1.803	3.044	2.848	3.598	3.559	3.918
Median	0.112	0.487	0.922	1.346	1.807	2.160	2.343	2.705	3.171
Average	0.107	0.473	0.892	1.346	1.776	2.122	2.454	2.692	3.167

Table 18. Statistical properties of estimates of population abundance (numbers in 000's) at time 2005 and survey calibration constants (unitless, survey:population) for haddock in unit areas 5Zjm obtained from a bootstrap with 1000 replications.

Age	Estimate	Standard Error	Relative Error	Bias	Relative Bias
		Population Abundance (000's)			
1	8971	5267	0.587	1053	0.117
2	321419	129007	0.401	23295	0.072
3	1129	345	0.305	56	0.050
4	2167	623	0.288	104	0.048
5	25053	6304	0.252	663	0.026
6	3812	960	0.252	35	0.009
7	3789	1209	0.319	69	0.018
8	816	317	0.389	51	0.063
		Survey Calibration Constants			
DFO Survey					
1	0.216	0.047	0.219	0.004	0.019
2	0.414	0.089	0.214	0.006	0.016
3	0.884	0.186	0.210	0.016	0.019
4	0.848	0.173	0.204	0.017	0.020
5	0.983	0.196	0.199	0.010	0.011
6	0.848	0.172	0.203	0.008	0.009
7	1.052	0.231	0.220	0.044	0.042
8	1.052	0.211	0.201	0.015	0.014
NMFS Spring Survey – Yankee 36 – 1969-72/1982-2004					
1	0.126	0.022	0.173	0.001	0.009
2	0.330	0.058	0.176	0.002	0.007
3	0.439	0.077	0.176	0.004	0.009
4	0.426	0.075	0.175	0.005	0.011
5	0.475	0.082	0.172	0.001	0.001
6	0.385	0.064	0.166	0.002	0.005
7	0.415	0.073	0.177	0.006	0.014
8	0.474	0.087	0.184	0.006	0.013
NMFS Spring Survey – Yankee 41 – 1973-81					
1	0.221	0.078	0.352	0.014	0.062
2	0.505	0.159	0.315	0.023	0.045
3	0.632	0.214	0.338	0.039	0.062
4	0.788	0.264	0.335	0.045	0.058
5	0.930	0.321	0.345	0.050	0.053
6	0.884	0.337	0.381	0.045	0.051
7	1.362	0.491	0.360	0.079	0.058
8	0.639	0.233	0.365	0.055	0.086
NMFS Fall Survey					
0	0.124	0.019	0.155	0.001	0.011
1	0.289	0.047	0.164	0.003	0.010
2	0.231	0.037	0.160	0.002	0.008
3	0.230	0.035	0.154	0.003	0.011
4	0.179	0.030	0.165	0.001	0.006
5	0.159	0.026	0.162	0.001	0.007

Table 19. Beginning of year population abundance (numbers in 000's) for haddock in unit areas 5Zjm during 1969-2005 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2005.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	804	199	4162	866	904	8720	2911	186	793	19545	18741	18542
1970	3464	658	147	2112	474	444	4554	1644	469	13966	10502	9844
1971	562	2772	460	114	1416	252	246	2693	1228	9743	9181	6409
1972	5626	370	1161	153	65	937	65	61	2167	10605	4979	4609
1973	11556	4286	302	601	60	35	686	18	1413	18958	7401	3115
1974	3406	8457	1903	242	159	15	20	526	1015	15743	12336	3880
1975	3274	2752	4884	1315	198	101	10	16	1182	13731	10457	7706
1976	54858	2659	1990	2631	883	158	51	6	951	64189	9331	6672
1977	5906	44481	2036	1475	1414	602	129	25	768	56837	50931	6450
1978	4210	4823	29090	1608	1045	890	350	106	623	42745	38535	33712
1979	52752	3438	3666	14613	1165	702	458	213	580	77586	24834	21396
1980	6715	42892	2794	2812	8109	627	399	184	598	65129	58414	15522
1981	5186	5459	19140	1981	2033	4509	342	214	583	39448	34262	28803
1982	1776	4192	3833	9615	1267	1221	2599	175	618	25296	23520	19328
1983	2632	1450	2753	2186	5305	850	663	1476	537	17851	15219	13769
1984	15257	2140	1047	1650	1291	2875	510	448	1258	26477	11220	9079
1985	1616	12406	1663	624	1036	818	1353	254	970	20739	19123	6717
1986	13662	1313	8148	1004	347	670	556	771	850	27321	13659	12346
1987	1310	11098	1037	4359	668	157	439	352	1137	20558	19248	8150
1988	15549	1071	7217	731	2188	456	76	285	1056	28628	13079	12009
1989	806	12655	828	3916	487	1003	275	28	967	20966	20160	7505
1990	2516	656	9234	600	2521	280	529	198	756	17291	14775	14118
1991	1889	2036	530	6356	377	1385	168	285	705	13731	11842	9806
1992	8458	1524	1245	351	3316	227	781	74	625	16599	8141	6617
1993	11912	6864	1019	730	174	1402	108	353	466	23027	11115	4250
1994	14028	9663	5348	514	346	65	577	58	469	31068	17040	7377
1995	4867	11428	7625	3666	280	231	8	354	367	28827	23960	12532
1996	6415	3966	9270	5737	2614	180	166	4	528	28880	22465	18499
1997	16862	5237	3212	7126	3891	1748	90	119	365	38650	21788	16551
1998	9168	13738	4192	2551	5322	2731	1250	62	357	39371	30203	16465
1999	27879	7468	11047	3153	1841	3845	1815	917	300	58266	30387	22919
2000	12824	22747	6067	8338	2288	1280	2832	1253	885	58513	45688	22942
2001	65607	10469	18318	4555	5668	1645	862	2124	1523	110770	45163	34694
2002	3900	53560	8502	13392	3242	3866	1109	521	2593	90684	86785	33225
2003	1635	3184	43486	6751	9228	2311	2553	806	2195	72149	70514	67330
2004	365482	1331	2592	33891	5264	6205	1505	1655	2153	420076	54594	53263
2005	7918	298124	1073	2063	24389	3777	3721	765	2498	344327	336409	38285

Table 20. Fishing mortality rate for haddock in unit areas 5Zjm during 1969-2004 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2005. The rate for ages 4+ is weighted by population numbers and is also shown as exploitation rate (%).

Year	Age Group										
	1	2	3	4	5	6	7	8	9+	4+	4+ (%)
1969	0.001	0.107	0.479	0.403	0.510	0.450	0.371	0.753	0.490	0.441	33
1970	0.023	0.157	0.055	0.200	0.432	0.389	0.325	0.284	0.583	0.312	24
1971	0.217	0.671	0.901	0.355	0.213	1.152	1.197	0.370	0.445	0.415	31
1972	0.072	0.004	0.458	0.736	0.435	0.112	1.065	0.329	0.253	0.256	21
1973	0.112	0.612	0.023	1.131	1.175	0.364	0.065	0.686	0.139	0.361	28
1974	0.014	0.349	0.170	0.000	0.251	0.200	0.014	0.061	0.068	0.073	6
1975	0.008	0.124	0.418	0.198	0.025	0.484	0.274	0.185	0.028	0.125	11
1976	0.010	0.067	0.100	0.421	0.183	0.000	0.522	0.000	0.020	0.281	22
1977	0.003	0.225	0.036	0.144	0.263	0.344	0.001	1.016	0.021	0.189	16
1978	0.003	0.074	0.488	0.122	0.198	0.466	0.294	0.109	0.016	0.204	17
1979	0.007	0.007	0.065	0.389	0.420	0.365	0.713	0.250	0.027	0.385	29
1980	0.007	0.607	0.144	0.124	0.387	0.405	0.421	0.359	0.023	0.313	25
1981	0.013	0.154	0.489	0.247	0.309	0.351	0.469	0.180	0.014	0.301	24
1982	0.002	0.221	0.362	0.395	0.199	0.412	0.366	0.485	0.119	0.365	28
1983	0.007	0.125	0.312	0.327	0.413	0.311	0.191	0.353	0.073	0.350	27
1984	0.007	0.052	0.318	0.265	0.256	0.554	0.499	0.507	0.319	0.404	30
1985	0.007	0.220	0.305	0.387	0.235	0.186	0.363	0.261	0.140	0.263	21
1986	0.008	0.036	0.426	0.207	0.595	0.223	0.258	0.276	0.055	0.230	19
1987	0.002	0.230	0.150	0.489	0.182	0.524	0.233	0.246	0.115	0.373	28
1988	0.006	0.057	0.411	0.206	0.580	0.308	0.791	0.193	0.109	0.374	28
1989	0.005	0.115	0.122	0.240	0.353	0.439	0.130	1.644	0.053	0.253	20
1990	0.012	0.014	0.173	0.266	0.399	0.310	0.419	0.266	0.063	0.322	25
1991	0.015	0.292	0.212	0.451	0.308	0.374	0.628	0.823	0.100	0.421	31
1992	0.009	0.203	0.335	0.504	0.660	0.544	0.594	0.499	0.175	0.577	40
1993	0.009	0.050	0.484	0.546	0.776	0.688	0.424	0.635	0.187	0.574	40
1994	0.005	0.037	0.178	0.407	0.203	1.871	0.287	0.845	0.101	0.327	25
1995	0.005	0.009	0.085	0.138	0.244	0.130	0.503	0.180	0.052	0.141	12
1996	0.003	0.011	0.063	0.188	0.203	0.491	0.132	2.000	0.170	0.197	16
1997	0.005	0.023	0.030	0.092	0.154	0.136	0.179	0.079	0.112	0.117	10
1998	0.005	0.018	0.085	0.126	0.125	0.209	0.109	0.246	0.116	0.143	12
1999	0.003	0.008	0.081	0.121	0.164	0.106	0.171	0.127	0.096	0.130	11
2000	0.003	0.017	0.087	0.186	0.130	0.195	0.088	0.178	0.087	0.157	13
2001	0.003	0.008	0.113	0.140	0.183	0.194	0.304	0.129	0.156	0.169	14
2002	0.003	0.008	0.031	0.172	0.139	0.215	0.118	0.260	0.128	0.169	14
2003	0.006	0.006	0.049	0.049	0.197	0.229	0.234	0.160	0.122	0.154	13
2004	0.004	0.016	0.028	0.129	0.132	0.311	0.477	0.330	0.144	0.169	14

Table 21. Beginning of year biomass (mt in 000's) for haddock in unit areas 5Zjm during 1969-2005 from a virtual population analysis using the bootstrap bias adjusted population abundance at the beginning of 2005.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
1969	92	103	3892	1302	1800	20447	7906	545	2731	38817	38725	38622
1970	398	338	137	3176	944	1042	12369	4816	1617	24838	24440	24101
1971	65	1426	430	171	2821	590	669	7888	4230	18290	18226	16799
1972	647	190	1085	230	130	2197	177	179	7465	12300	11653	11462
1973	1328	2205	282	904	120	81	1863	54	4868	11706	10377	8172
1974	392	4351	1779	364	316	36	53	1542	3496	12328	11937	7586
1975	376	1416	4566	1978	394	237	28	46	4072	13113	12736	11321
1976	6306	1368	1861	3957	1760	371	139	19	3278	19057	12751	11383
1977	679	22887	1904	2217	2818	1412	351	73	2647	34988	34309	11422
1978	484	2482	27197	2419	2082	2087	950	310	2148	40158	39674	37192
1979	6064	1769	3428	21976	2321	1645	1243	625	1998	41068	35004	33235
1980	772	22069	2612	4228	16158	1469	1083	538	2061	50991	50219	28149
1981	596	2809	17895	2979	4050	10572	929	628	2010	42469	41873	39064
1982	204	2157	3583	14459	2524	2864	7060	513	2128	35493	35289	33132
1983	303	746	2574	3287	10570	1994	1800	4322	1850	27445	27143	26396
1984	1754	1101	979	2481	2572	6741	1386	1313	4333	22660	20906	19805
1985	186	6383	1555	938	2065	1919	3674	743	3340	20802	20616	14233
1986	1839	593	7939	1450	1055	1910	2001	2601	3329	22717	20878	20285
1987	197	5544	743	7290	1344	399	1382	1109	4127	22135	21939	16394
1988	1512	497	6715	1313	3974	875	207	929	4086	20108	18597	18099
1989	50	6000	538	5453	972	2534	593	81	3038	19259	19209	13209
1990	375	344	8534	709	4696	581	1327	556	2624	19746	19371	19026
1991	226	1394	424	9607	638	3372	354	890	2419	19325	19099	17705
1992	1034	918	1392	372	6891	491	2114	168	2148	15529	14495	13577
1993	1453	3302	1250	1316	221	3271	252	966	1527	13559	12106	8804
1994	1496	4534	5598	834	667	141	1819	155	1447	16691	15195	10661
1995	420	5639	7344	5704	622	566	20	1060	1170	22544	22124	16486
1996	889	1963	8519	7573	5050	459	482	11	1894	26840	25952	23989
1997	2229	2652	2511	8589	6474	3804	221	307	1153	27940	25711	23059
1998	984	7355	4339	2963	8354	5337	3261	219	1237	34050	33066	25712
1999	3615	3537	10061	4066	2318	7187	3867	2497	898	38046	34431	30894
2000	1484	12359	5755	12327	4280	2290	6508	3141	2567	50713	49229	36870
2001	6125	5481	18416	6244	10189	3561	1939	5509	4458	61922	55797	50316
2002	373	17759	6615	15236	4844	7596	2413	1149	7021	63006	62633	44874
2003	131	1176	36792	7176	13630	3801	5637	1797	5461	75601	75470	74293
2004	23353	413	2025	39016	6876	9668	2442	3236	4769	91798	68445	68032
2005	220	64917	529	1437	29903	4990	5696	1224	6105	115021	114800	49883

Table 22. Risk projection input for haddock in unit areas 5Zjm for the 2006 fishery and projection input for the 2006 to 2009 fishery. A catch of 23,000 mt in 2005 and M = 0.2 were assumed for the forecasts. Two projections were made, one using 20 million recruits for the 2005 to 2010 year classes, the other using 40 million.

Year	Age Group 1	2	3	4	5	6	7	8	9+
Population Numbers (000s)									
2005	7918	298124	1073	2063	24389	3777	3721	765	2498
Partial Recruitment to the Fishery[1]									
2005	0.02	0.05	0.17	0.57	1	1	1	1	1
2006	0.02	0.05	0.17	0.57	1	1	1	1	1
2007[4]	0.02	0.05	0.17	0.57	1	1	1	1	1
2008[4]	0.02	0.05	0.17	0.57	1	1	1	1	1
2009[4]	0.02	0.05	0.17	0.57	1	1	1	1	1
Weight at beginning of year for population (kg)[2]									
2005	0.03	0.22	0.49	0.7	1.23	1.32	1.53	1.6	2.44
2006	0.03	0.22	0.49	0.7	1.23	1.32	1.53	1.6	2.44
2007	0.03	0.22	0.49	0.7	1.23	1.32	1.53	1.6	2.44
2008[4]	0.03	0.22	0.49	0.7	1.23	1.32	1.53	1.6	2.44
2009[4]	0.03	0.22	0.49	0.7	1.23	1.32	1.53	1.6	2.44
2010[4]	0.03	0.22	0.49	0.7	1.23	1.32	1.53	1.6	2.44
Weight at age for catch (kg)[3]									
2005	0.45	0.79	1.3	1.62	1.81	2.04	2.33	2.5	3.17
2006	0.45	0.79	1.3	1.62	1.81	2.04	2.33	2.5	3.17
2007[4]	0.45	0.79	1.3	1.62	1.81	2.04	2.33	2.5	3.17
2008[4]	0.45	0.79	1.3	1.62	1.81	2.04	2.33	2.5	3.17
2009[4]	0.45	0.79	1.3	1.62	1.81	2.04	2.33	2.5	3.17
Maturity[5]									
2005	0	0	1	1	1	1	1	1	1
2006	0	0	1	1	1	1	1	1	1
2007	0	0	1	1	1	1	1	1	1

[1]Average of 2002 – 2004 for ages 1 to 4
[2]Equal to 2005 from DFO survey
[3]Average of 2002 – 2004 from Canadian fishery
[4]2006-2008 projection only
[5]Risk projection only

Table 23. Projection results for haddock in unit areas 5Zjm for the 2006 to 2009 fishery using 20 million recruits for the 2005 to 2010 year classes, 2002 to 2004 average fishery weights at age for catch biomass and the 2005 DFO survey weights at age for population biomass.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2005	7918	298124	1073	2063	24389	3777	3721	765	2498			
2006	20000	6438	239906	828	1387	14139	2190	2157	1891			
2007	20000	16290	5203	187926	585	876	8926	1382	2555			
2008	20000	16290	13165	4076	132668	369	553	5635	2486			
2009	20000	16290	13165	10312	2877	83751	233	349	5126			
2010	20000	16290	13165	10312	7280	1816	52871	147	3456			
Population Biomass (mt)												
2005	222	64991	529	1436	29901	4990	5696	1223	6104	115092	114870	49879
2006	560	1404	118274	576	1701	18677	3352	3451	4622	152617	152057	150654
2007	560	3551	2565	130797	717	1157	13665	2212	6246	161469	160909	157358
2008	560	3551	6490	2837	162651	488	846	9015	6075	192514	191954	188402
2009	560	3551	6490	7177	3528	110635	357	558	12529	145385	144825	141274
2009	560	3551	6490	7177	8925	2399	80945	235	8448	118731	118171	114620
Projected Catch Numbers (000s)												
2005	49	4625	55	335	6490	1005	990	203	665			
2006	94	75	9408	104	289	2947	456	450	394			
2007	94	191	204	23519	122	183	1860	288	533			
2008	94	191	516	510	27649	77	115	1174	518			
2009	94	191	516	1291	600	17454	49	73	1068			
Catch Biomass (mt)												
2005	22	3631	72	543	11754	2048	2311	508	2110	23000		
2006	43	59	12231	168	524	6005	1065	1123	1251	22469		
2007	43	150	265	38148	221	372	4342	720	1690	45950		
2008	43	150	671	827	50072	157	269	2934	1644	56767		
2009	43	150	671	2093	1086	35572	113	182	3391	43300		

Table 24. Projection results for haddock in unit areas 5Zjm for the 2006 to 2009 fishery using 40 million recruits for the 2005 to 20010 year classes, 2002 to 2004 average fishery weights at age for catch biomass and the 2005 DFO survey weights at age for population biomass.

Year	Age Group											
	1	2	3	4	5	6	7	8	9+	1+	2+	3+
Population Numbers (000s)												
2005	7918	298124	1073	2063	24389	3777	3721	765	2498			
2006	40000	6438	239906	828	1387	14139	2190	2157	1891			
2007	40000	32579	5203	187926	585	876	8928	1382	2555			
2008	40000	32579	26329	4076	132668	369	553	5635	2486			
2009	40000	32579	26329	20624	2877	83751	233	349	5126			
2010	40000	32579	26329	20624	14560	1816	52871	147	3456			
Population Biomass (mt)												
2005	222	64991	529	1436	29901	4990	5696	1223	6104	115092	114870	49879
2006	1120	1404	118274	576	1701	18677	3352	3451	4622	153177	152057	150654
2007	1120	7102	2565	130797	717	1157	13665	2212	6246	165580	164460	157358
2008	1120	7102	12980	2837	162651	488	848	9015	6075	203115	201995	194893
2009	1120	7102	12980	14355	3528	110635	357	558	12529	163164	162044	154941
2009	1120	7102	12980	14355	17851	2399	80945	235	8448	145435	144315	137213
Projected Catch Numbers (000s)												
2005	49	4625	55	335	6490	1005	990	203	665			
2006	188	75	9408	104	289	2947	456	450	394			
2007	188	381	204	23519	122	183	1860	288	533			
2008	188	381	1033	510	27649	77	115	1174	518			
2009	188	381	1033	2581	600	17454	49	73	1068			
Catch Biomass (mt)												
2005	22	3631	72	543	11754	2048	2311	508	2110	23000		
2006	85	59	12231	168	524	6005	1065	1123	1251	22512		
2007	85	299	265	38148	221	372	4342	720	1690	46142		
2008	85	299	1342	827	50072	157	269	2934	1644	57631		
2009	85	299	1342	4187	1086	35572	113	182	3391	46257		

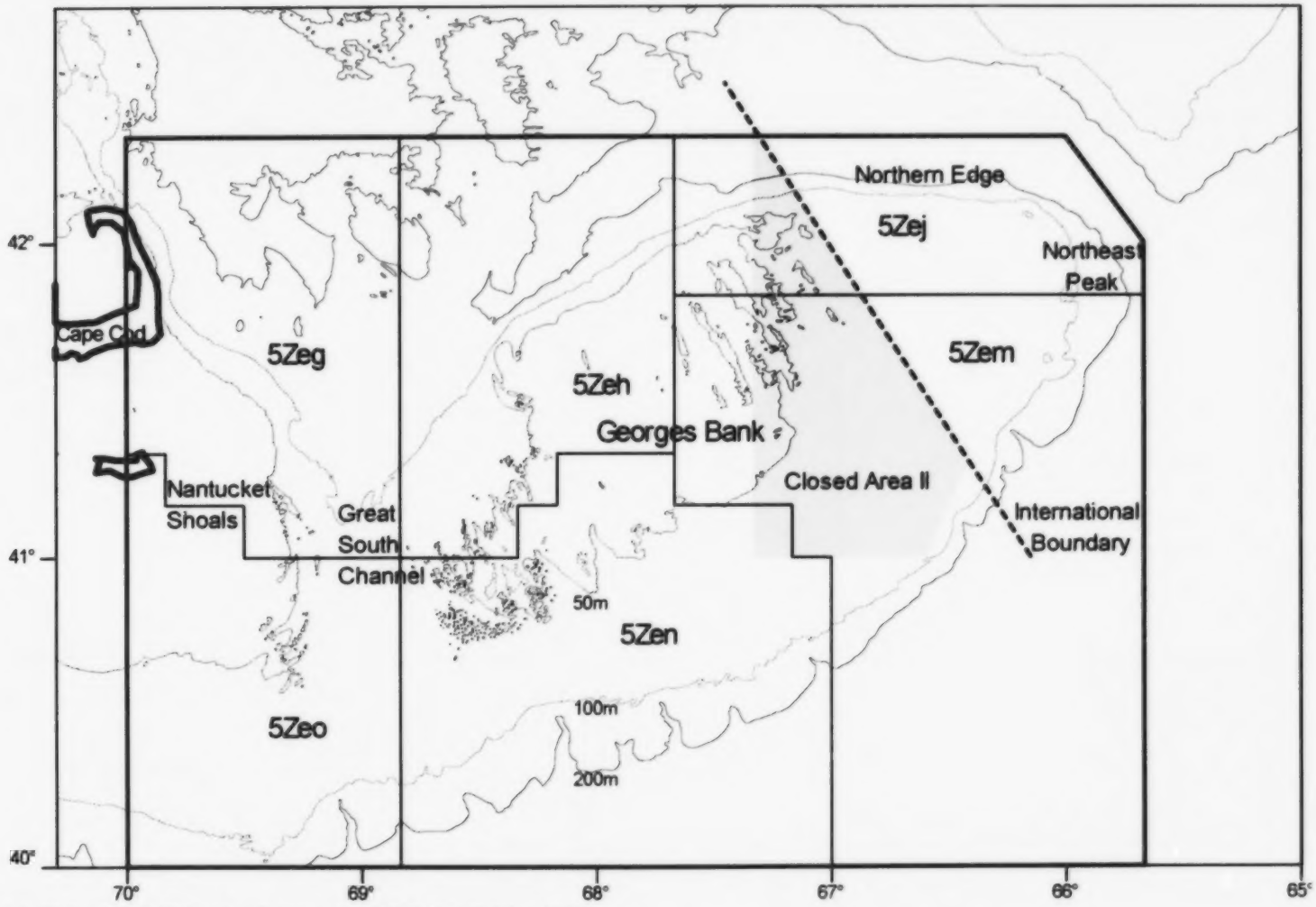

Figure 1. Fisheries statistical unit areas in NAFO Subdivision 5Ze.

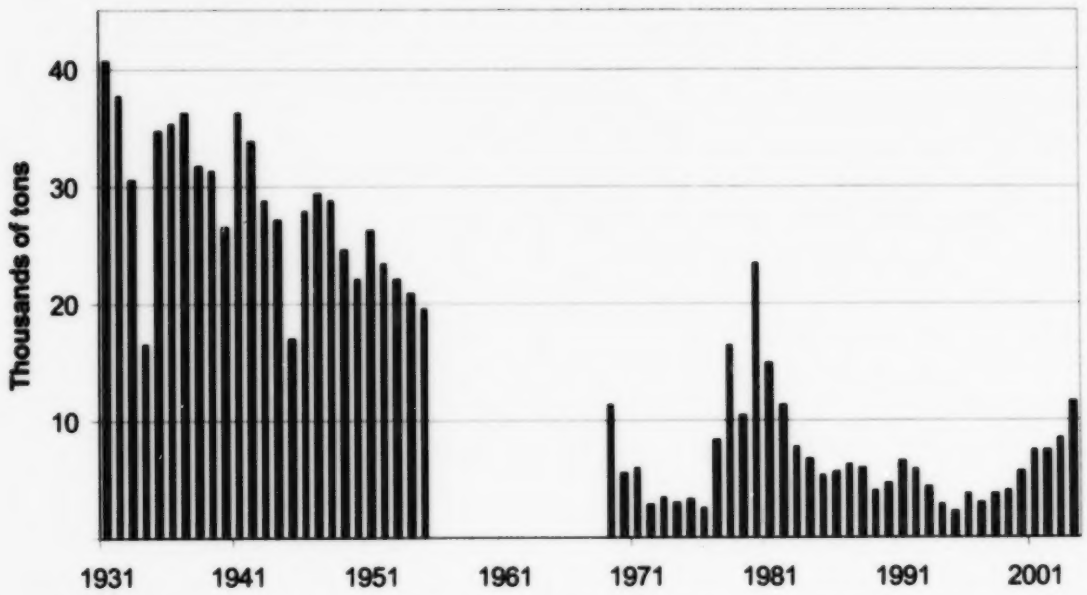

Figure 2. Historical catch of haddock in 5Zjm during 1931-1955 compared to recent catches during 1969-2004.

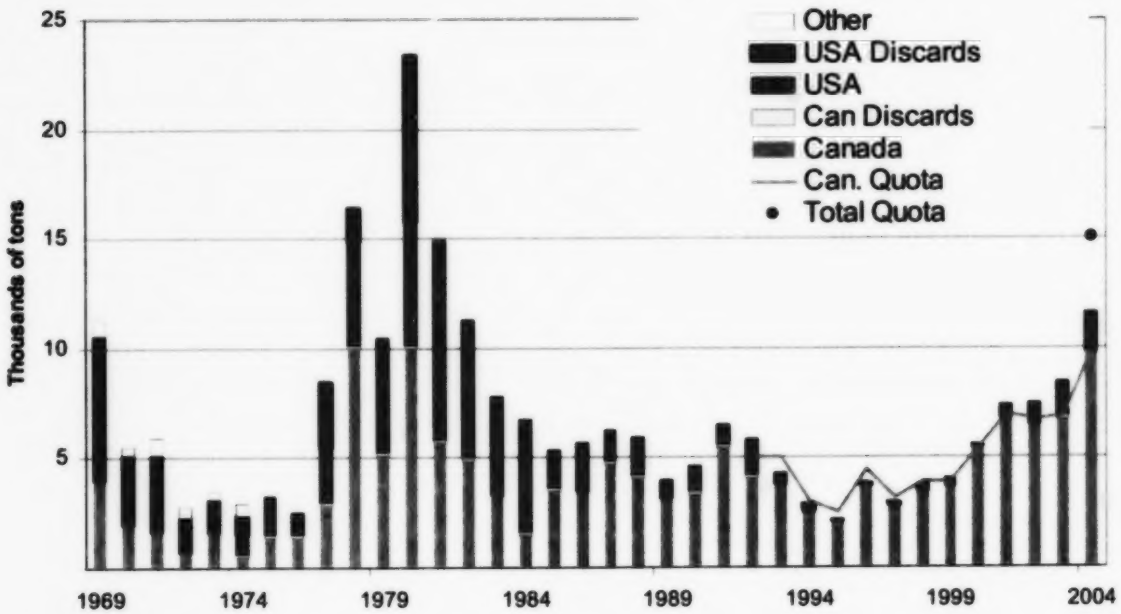

Figure 3. Nominal catch of haddock in unit areas 5Zjm during 1969-2004.

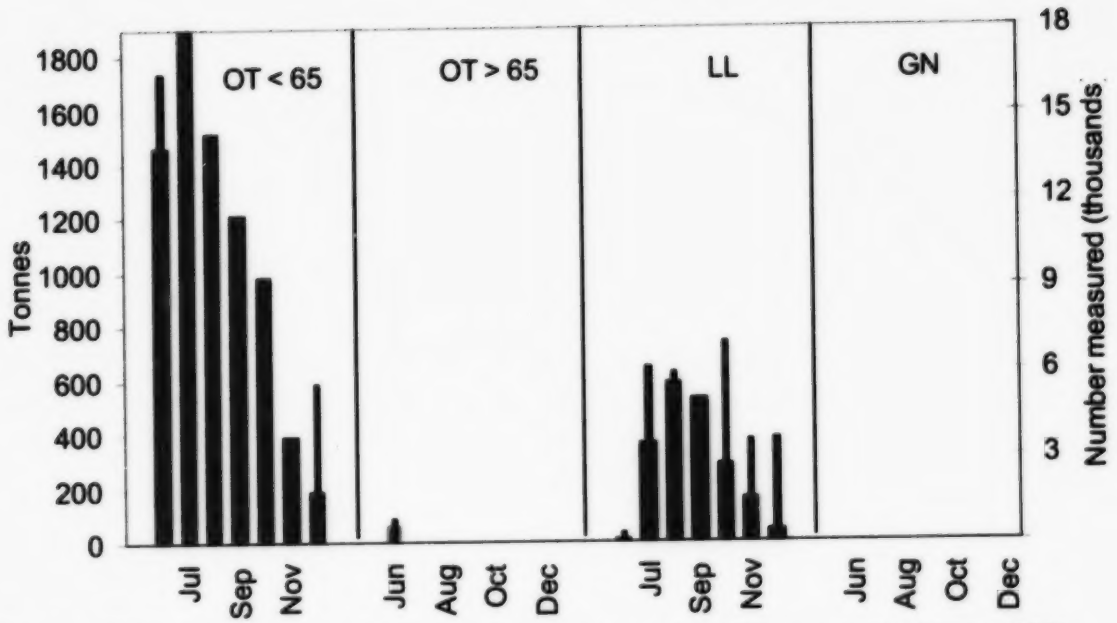

Figure 4. Haddock catches in 5Zjm by month and gear for the Canadian commercial fishery in 2004 (wide gray bars) with sampling levels (narrow black bars).

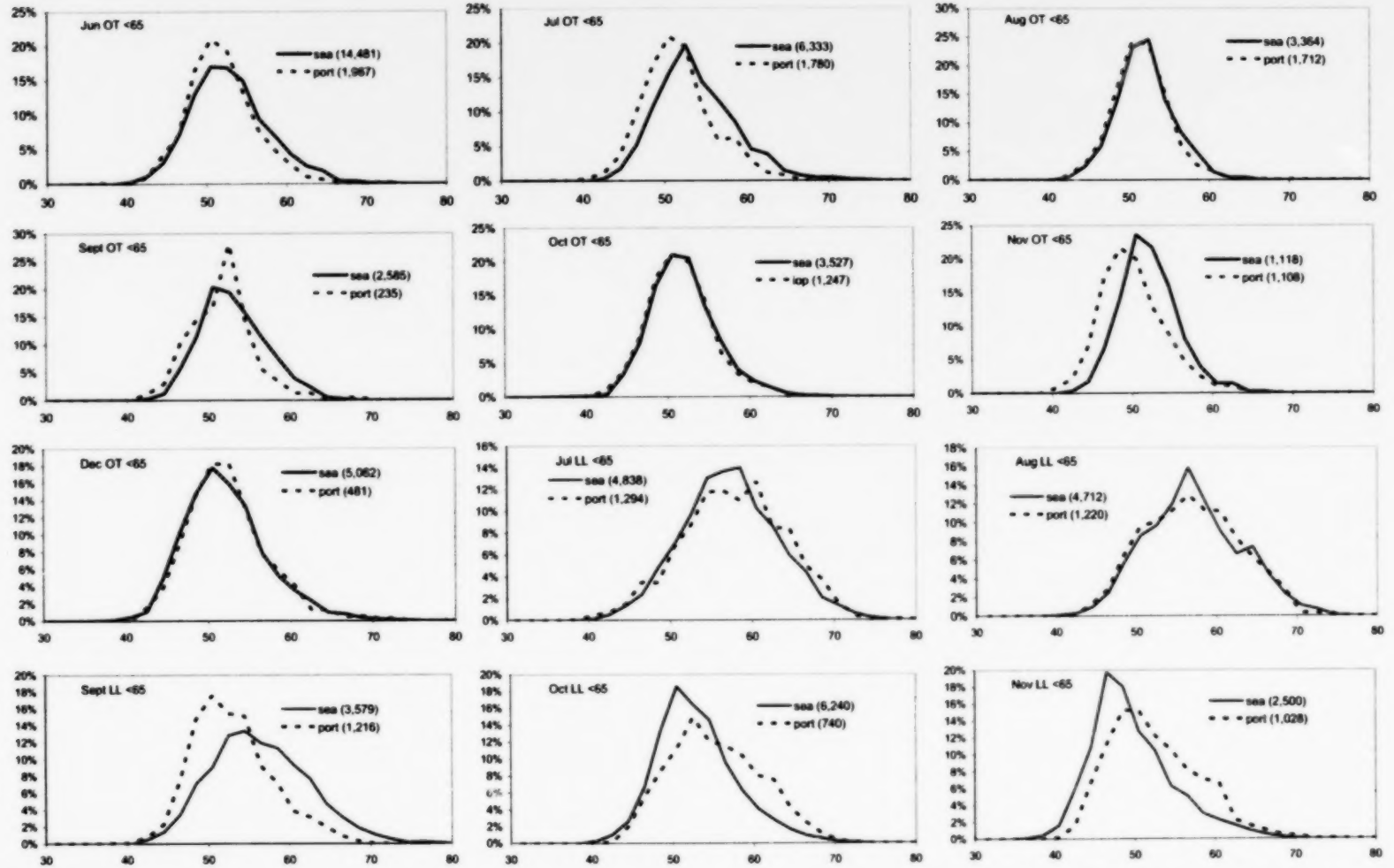

Figure 5. Comparison of length frequencies obtained at port and at sea from the Georges Bank Canadian commercial fishery in 2004. The number of fish measured is shown in brackets.

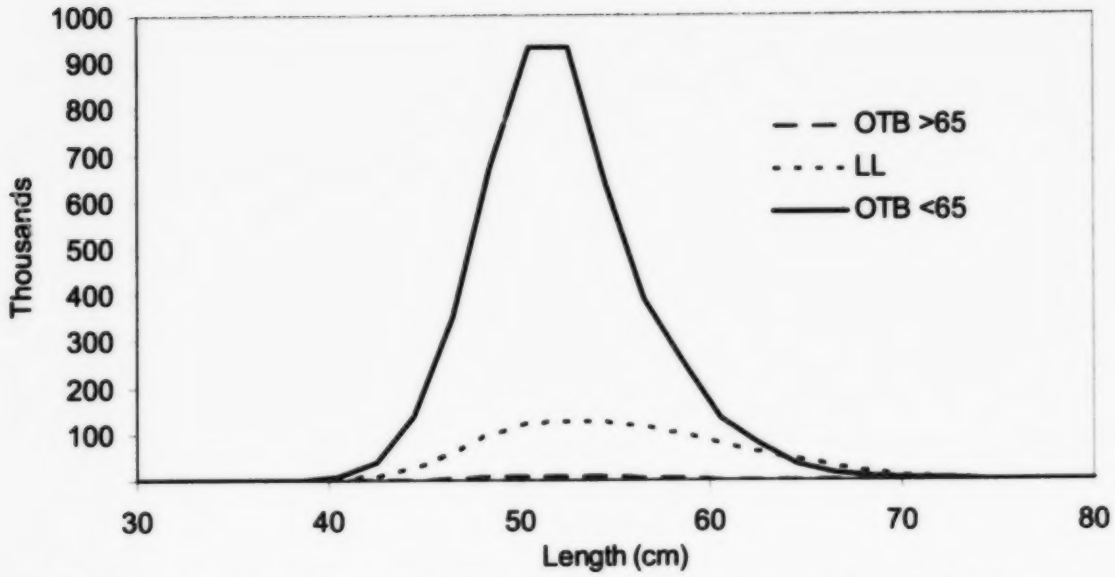

Figure 6. Catch at length by the principal Canadian 5Zjm commercial haddock fisheries in 2004.

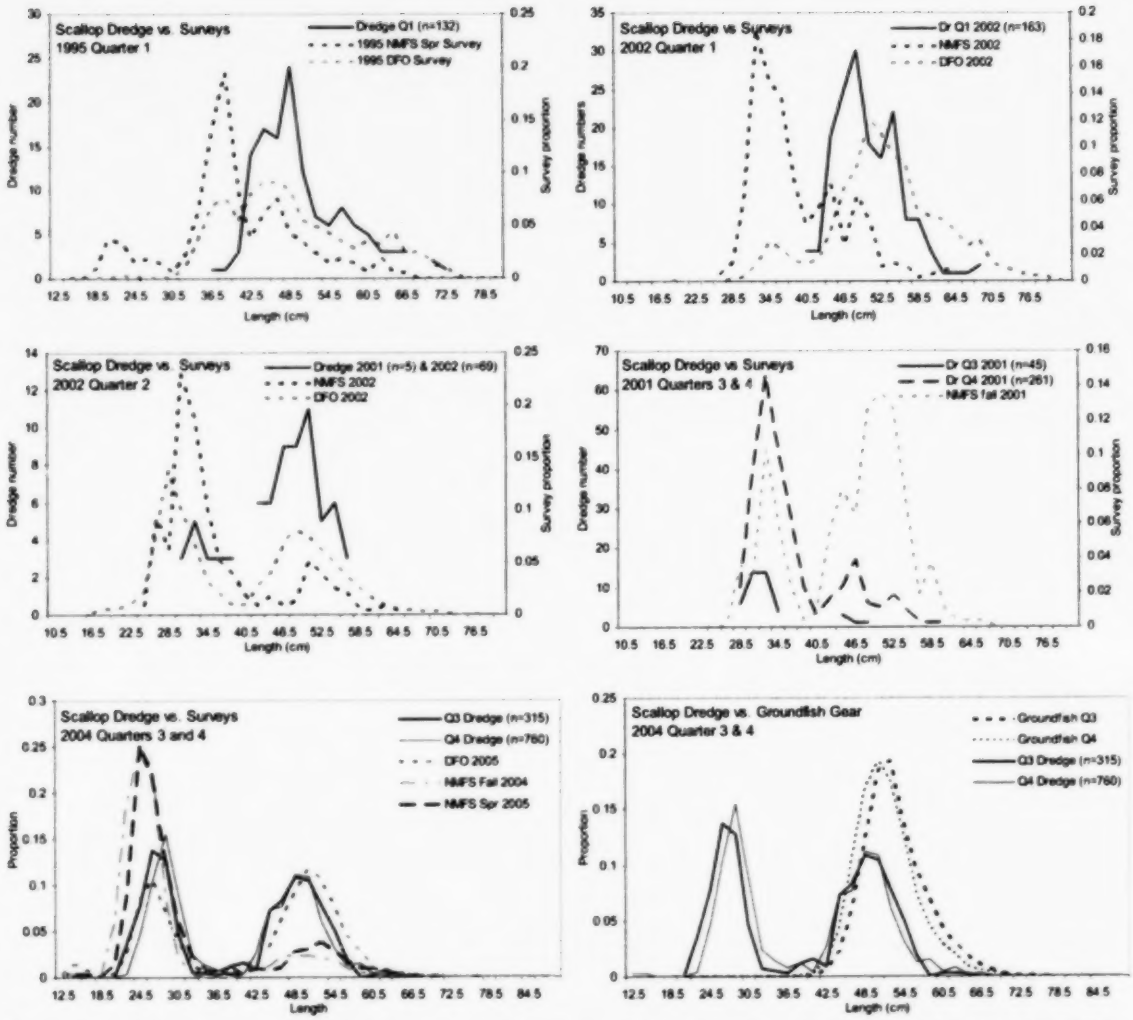

Figure 7. Comparison of haddock length frequencies by quarter from observed scallop fishery trips with survey and groundfishery length frequencies for scallop trips observed in 1995, 2001, 2002 and 2004. The 1995, 2001 and 2002 scallop dredge length frequencies were compared to that portion of the survey area which most closely matched the scallop dredge fishing locations. The 2004 dredge data were compared to the length frequencies from the 5Zjm area. The comparisons indicate that scallop gear length frequencies are more similar to those from survey gear than commercial groundfish gear.

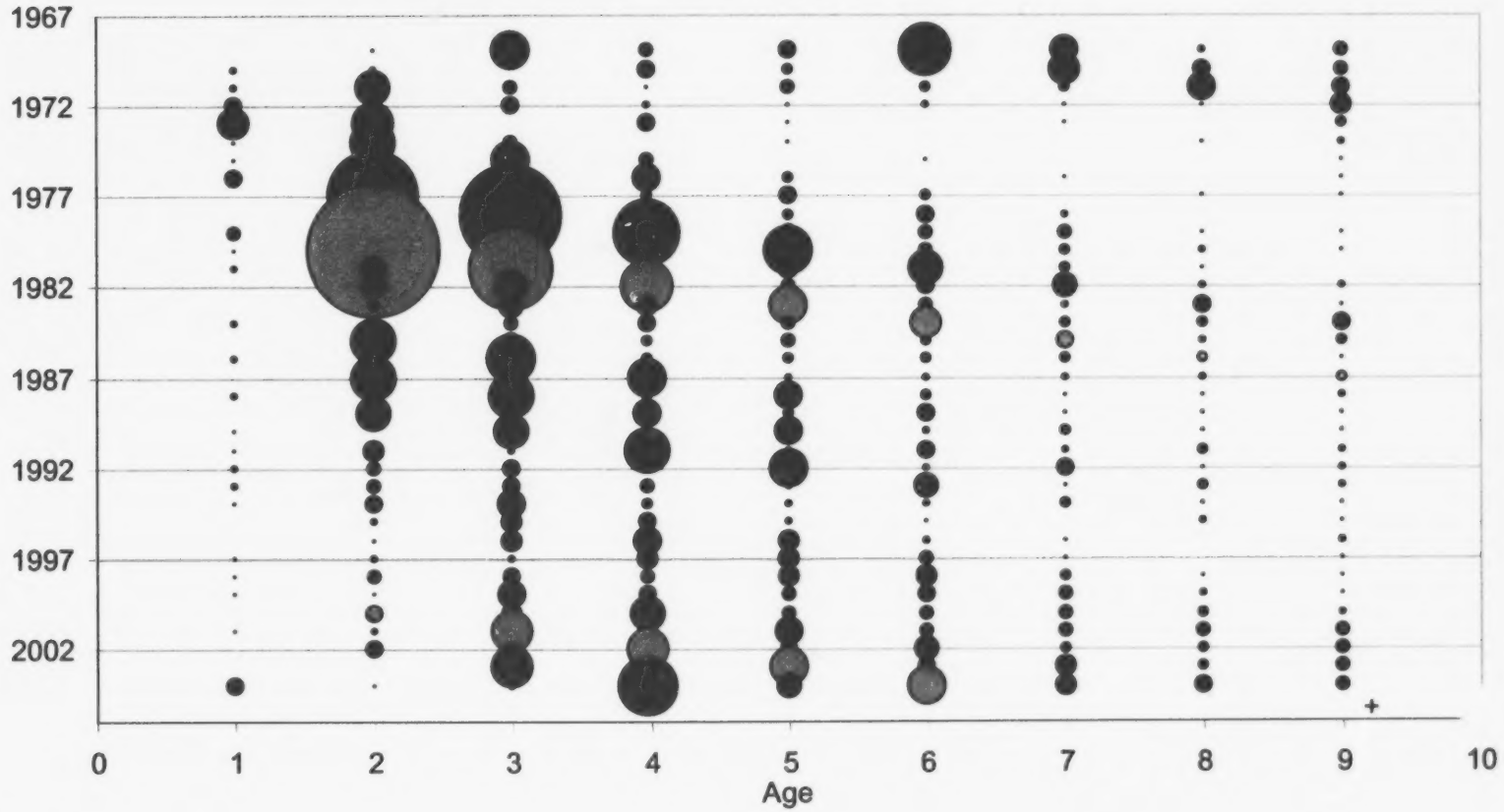

Figure 8. Total commercial catch at age (numbers) of haddock from unit areas 5Zjm during 1969-2004. The bubble area is proportional to magnitude (see Table 11).

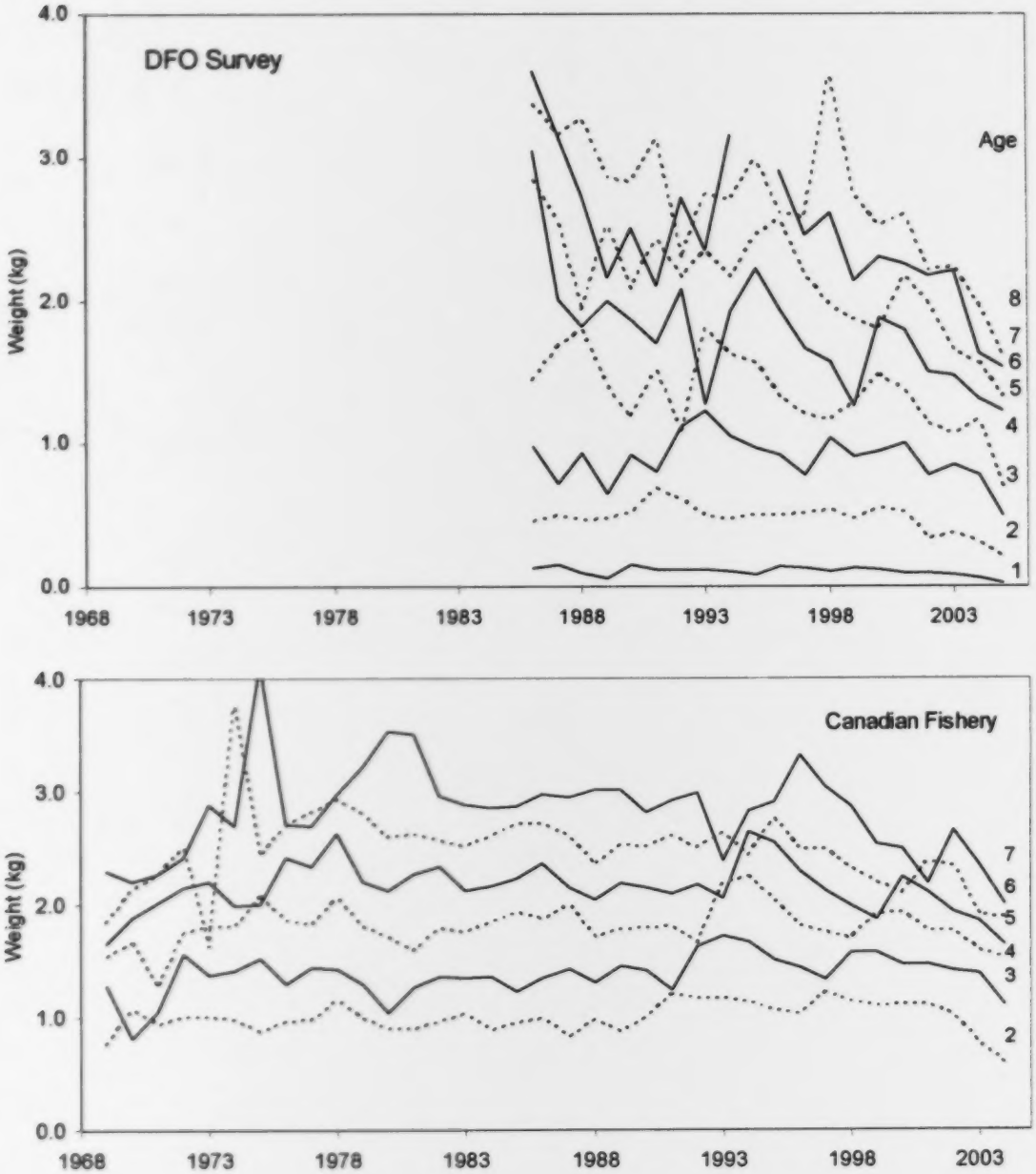

Figure 9. Average weights at age for haddock in unit areas 5Zjm from the Canadian commercial fishery during 1969-2004 and from the DFO survey during 1986-2005.

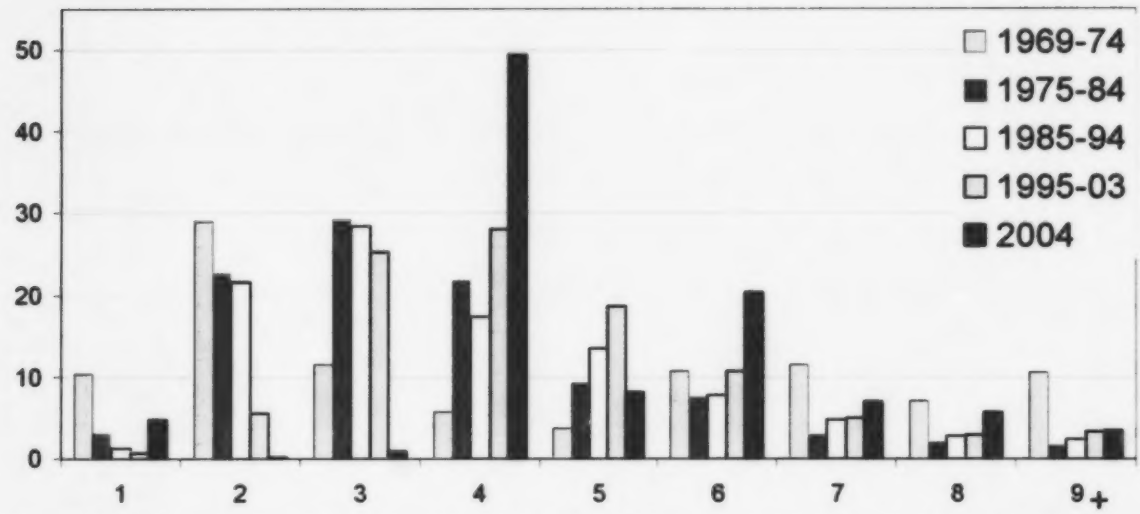

Figure 10. Age composition of the haddock catch for the 5Zjm commercial fishery in 2004 compared to the average age composition for the total catch of all fisheries during 1969-1974, 1975-1984, 1985-1994, and 1995-2003.

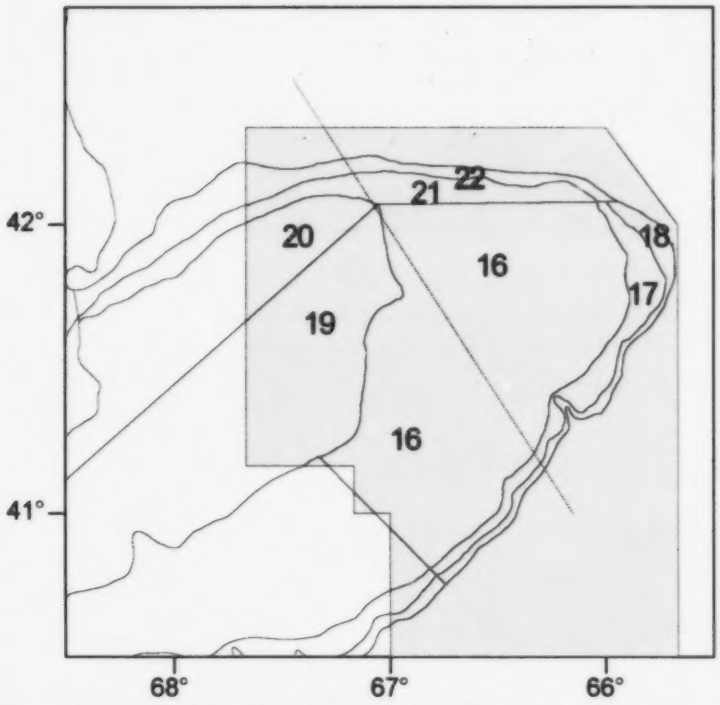

Figure 11. Stratification scheme used for NMFS surveys. The 5Zjm management area is indicated by shading.

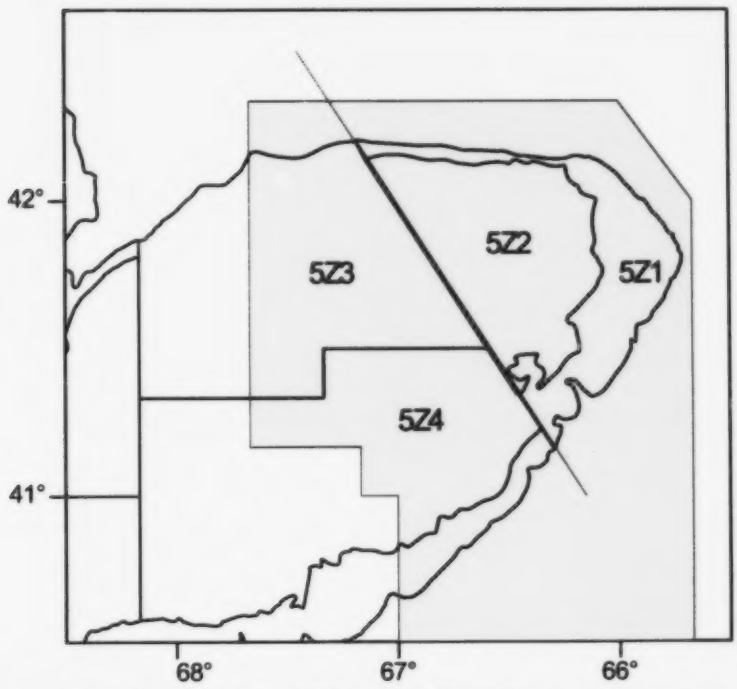

Figure 12. Stratification scheme used for the DFO survey. The 5Zjm management area is indicated by shading.

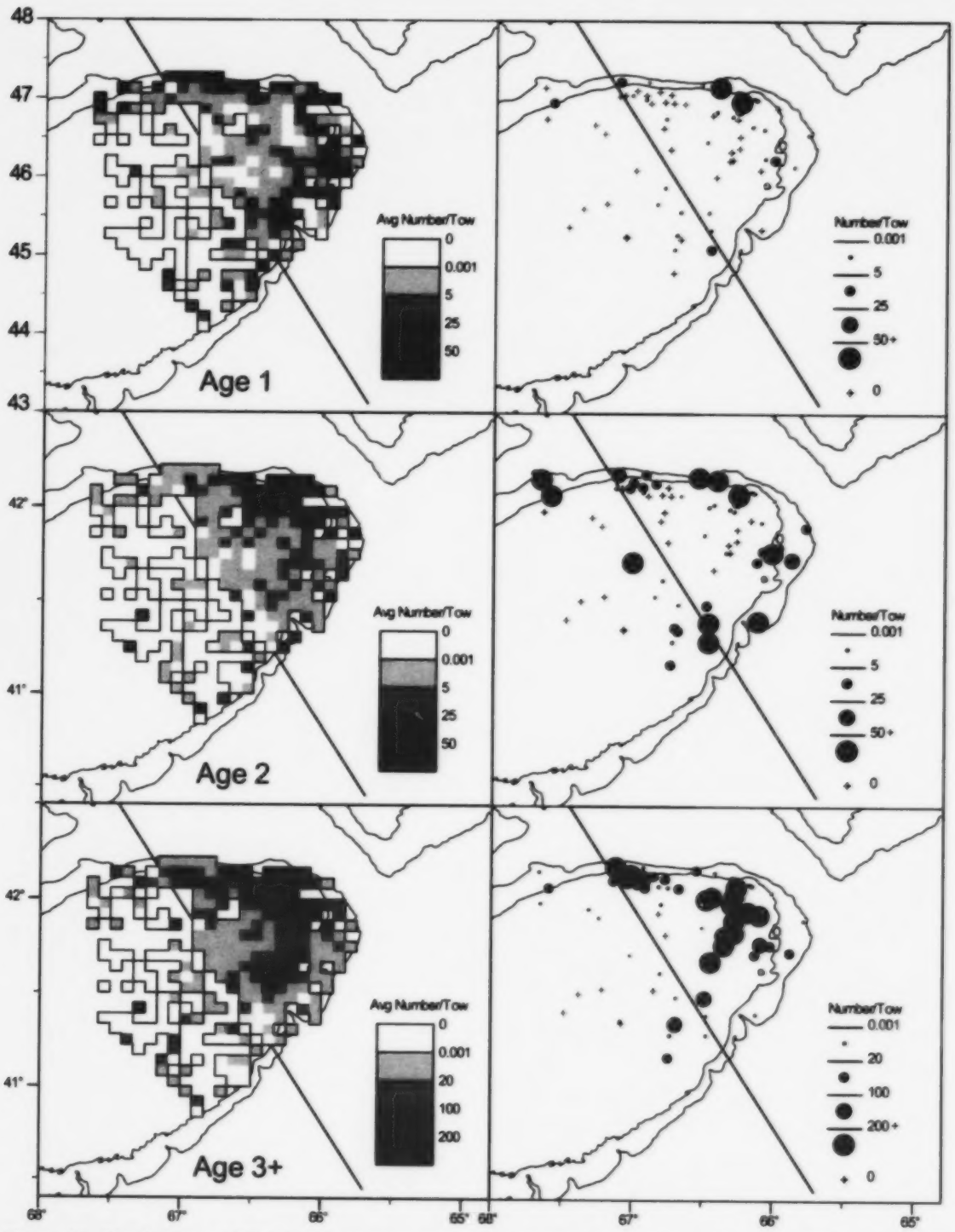

Figure 13. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **DFO** survey. The squares (left panels) are shaded relative to the average catch for 1995 to 2004. The expanding symbols (right panels) represent the **2005** survey catches.

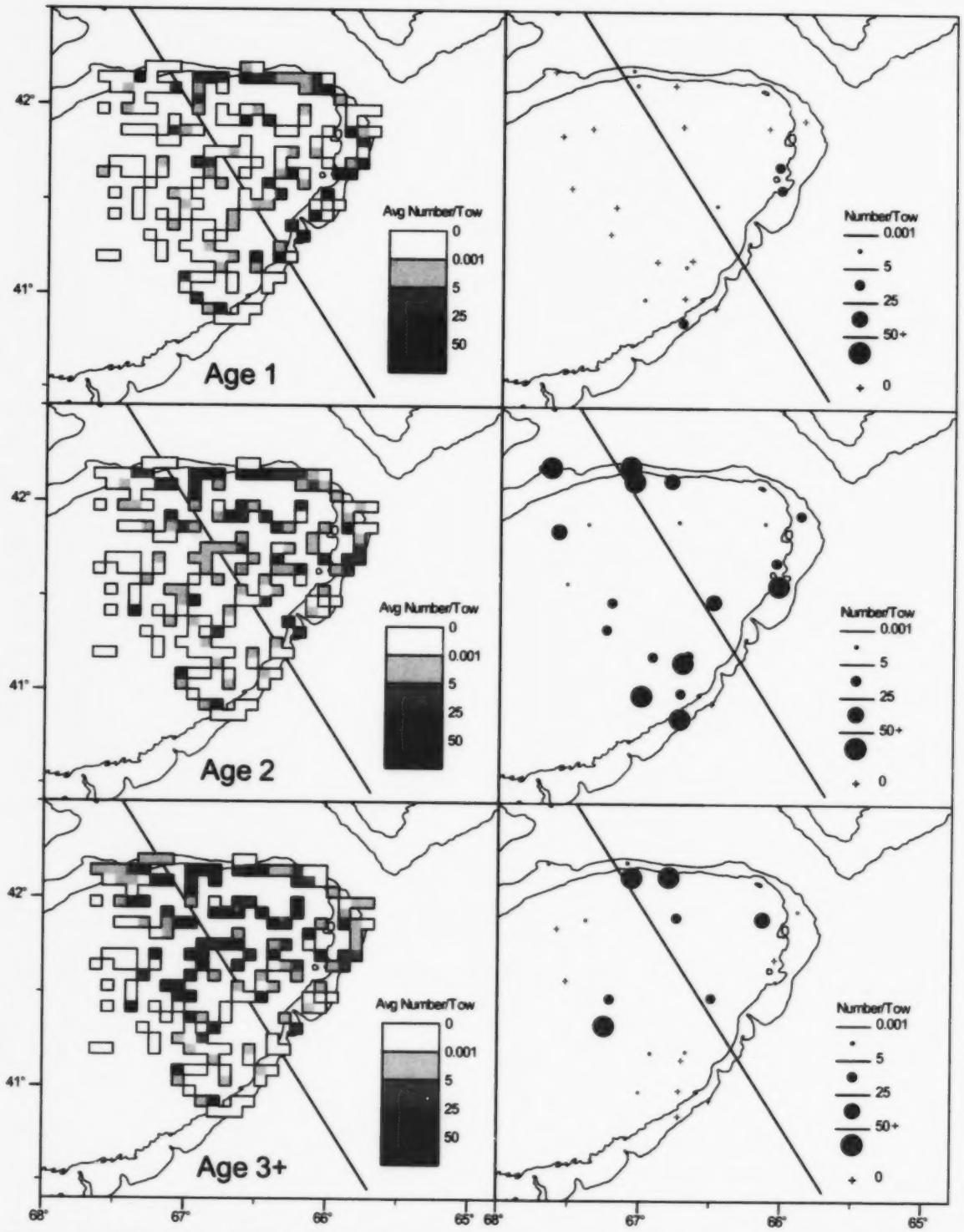

Figure 14. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS spring** survey. The squares (left panels) are shaded relative to the average catch for 1995 to 2004. The expanding symbols (right panels) represent the **2005** survey catches.

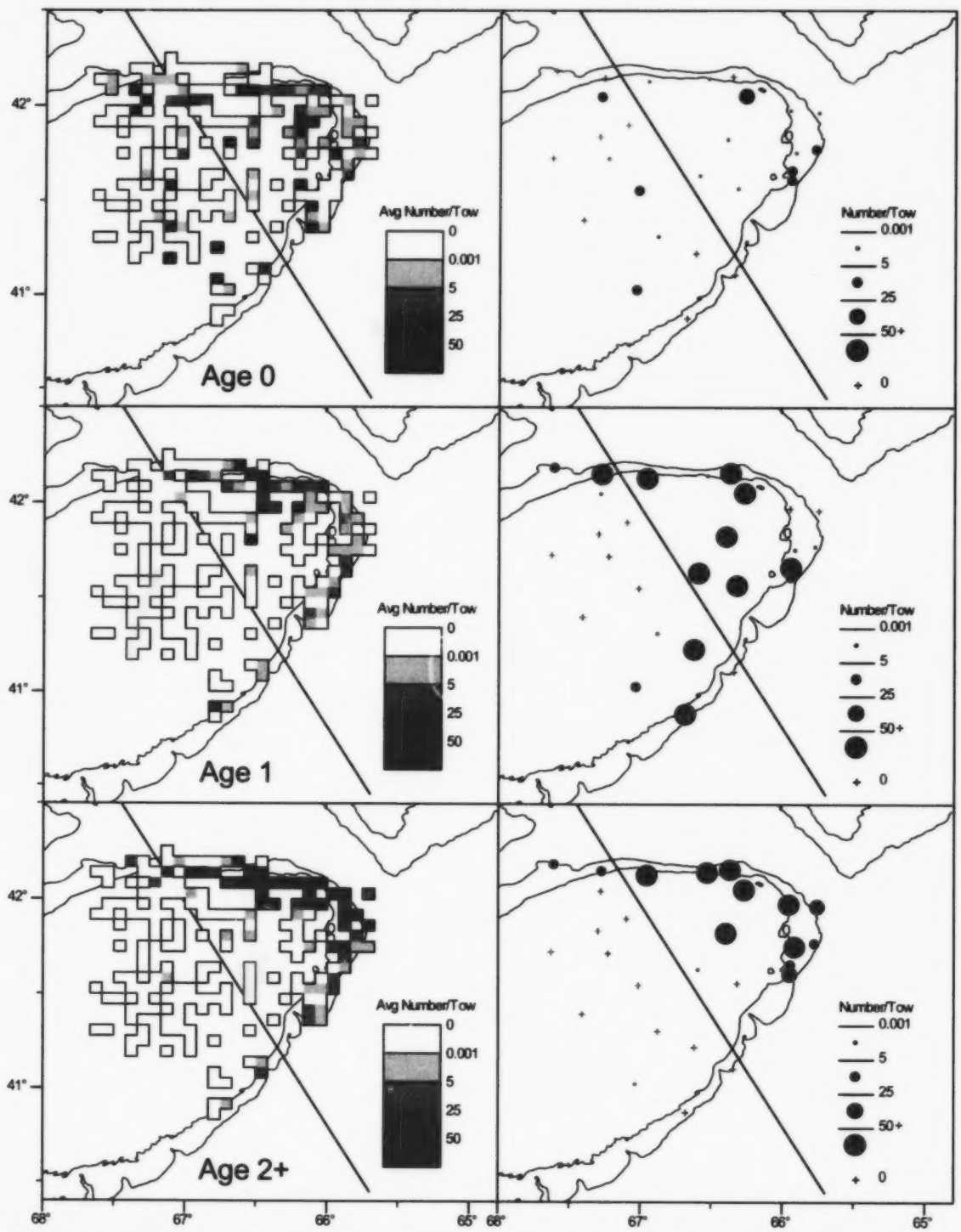

Figure 15. Distribution of 5Zjm haddock abundance (number/tow) as observed from the **NMFS fall** survey. The squares (left panels) are shaded relative to the average catch for 1994 to 2003. The expanding symbols (right panels) represent the **2004** survey catches.

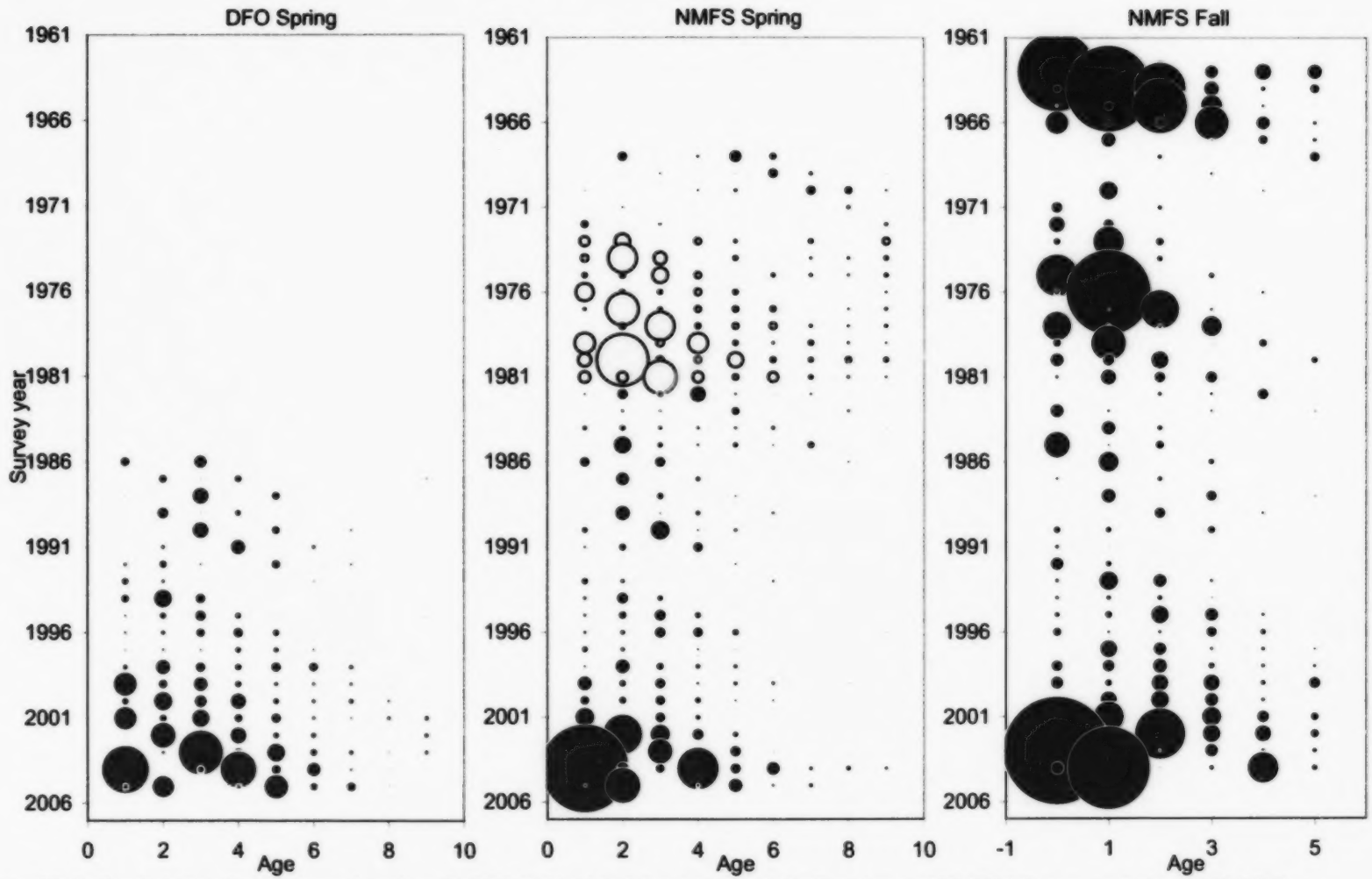

Figure 16. Estimated abundance at age (numbers in 000's) of haddock for the DFO, NMFS spring and NMFS fall surveys during 1963-2005. Bubble area is proportional to magnitude (see Tables 14-16). Conversion factors to adjust for changes in door type and survey vessel were applied to the NMFS surveys. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years. Symbol size has not been adjusted between surveys for the catchability of the survey.

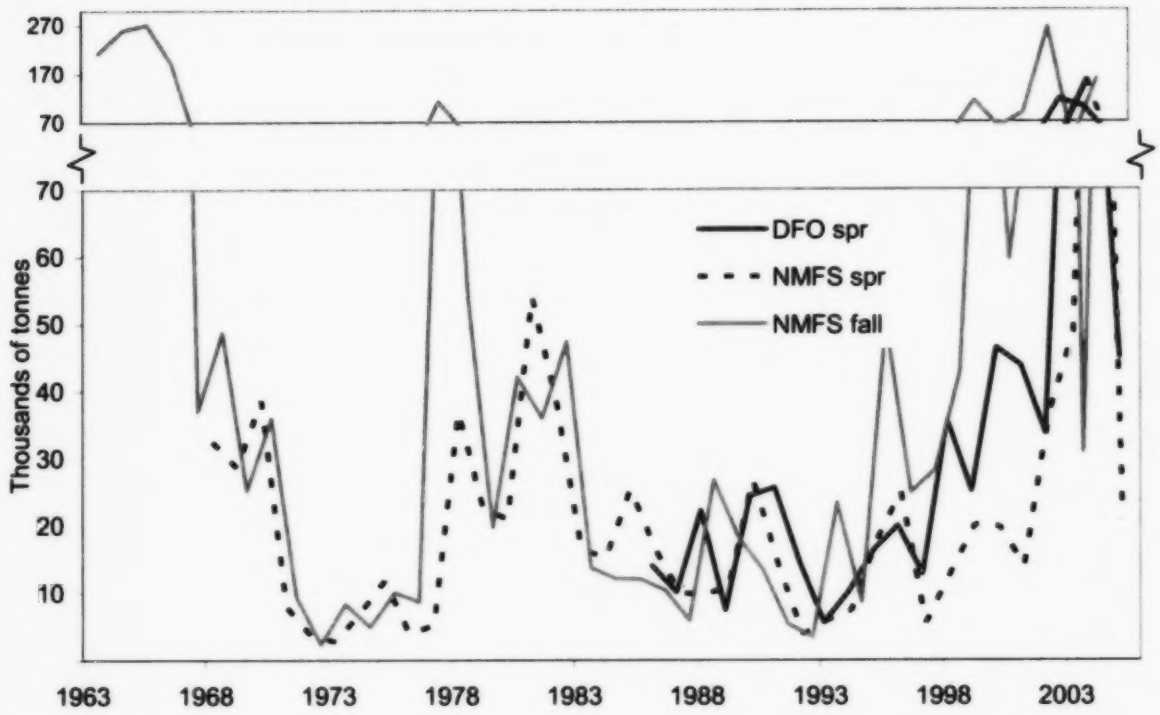

Figure 17. Biomass from NMFS fall (ages 2-8), NMFS spring (ages 3-8) and DFO (ages 3-8) research surveys (scaled by calibration constants, Table 18) for haddock in unit areas 5Zjm during 1963-2005.

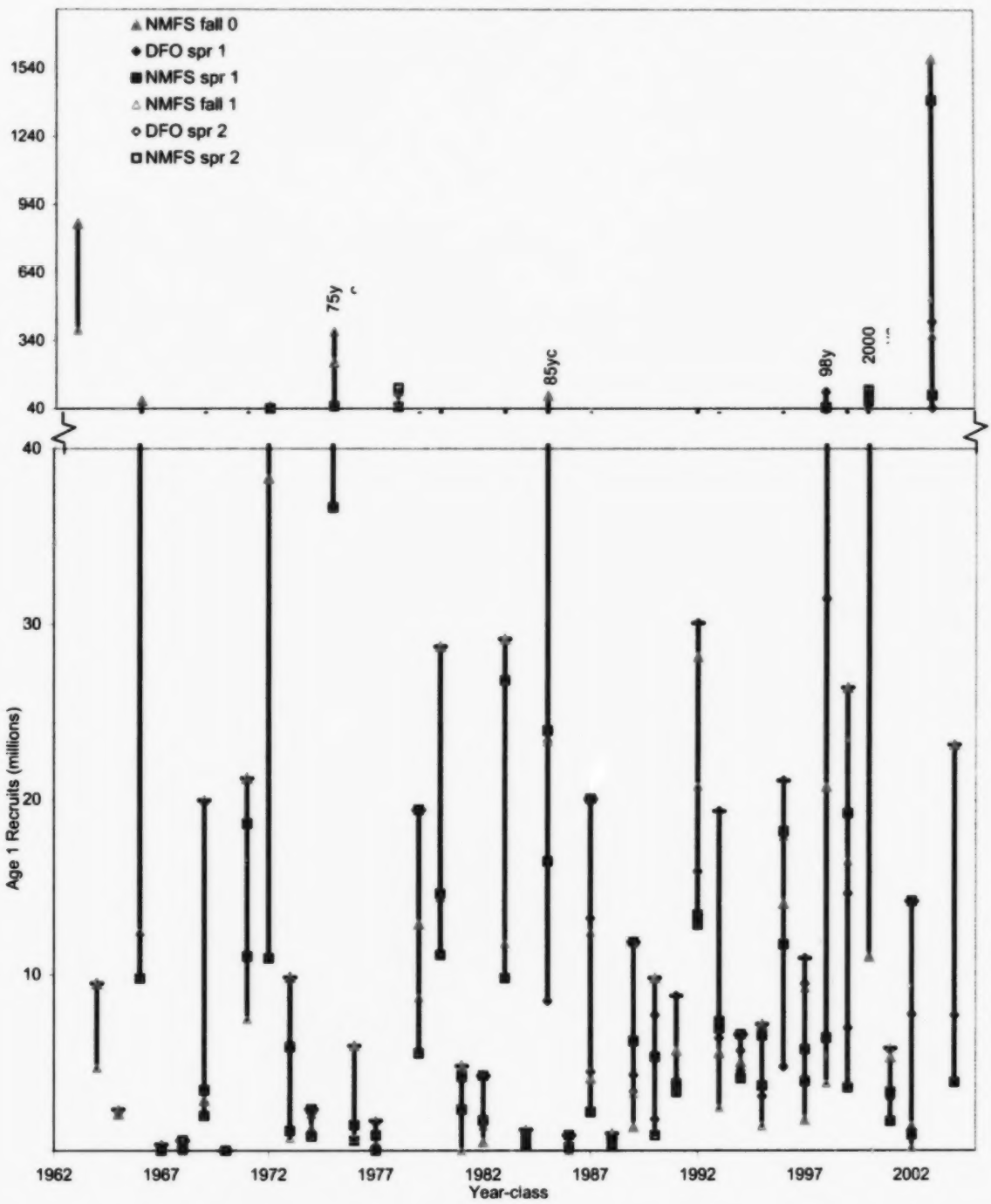

Figure 18. Year-class abundance for ages 0 and 1 from the NMFS fall and ages 1 and 2 from the NMFS spring and DFO research surveys (scaled by calibration constants, Table 16) for haddock in unit areas 5Zjm during 1963-2005.

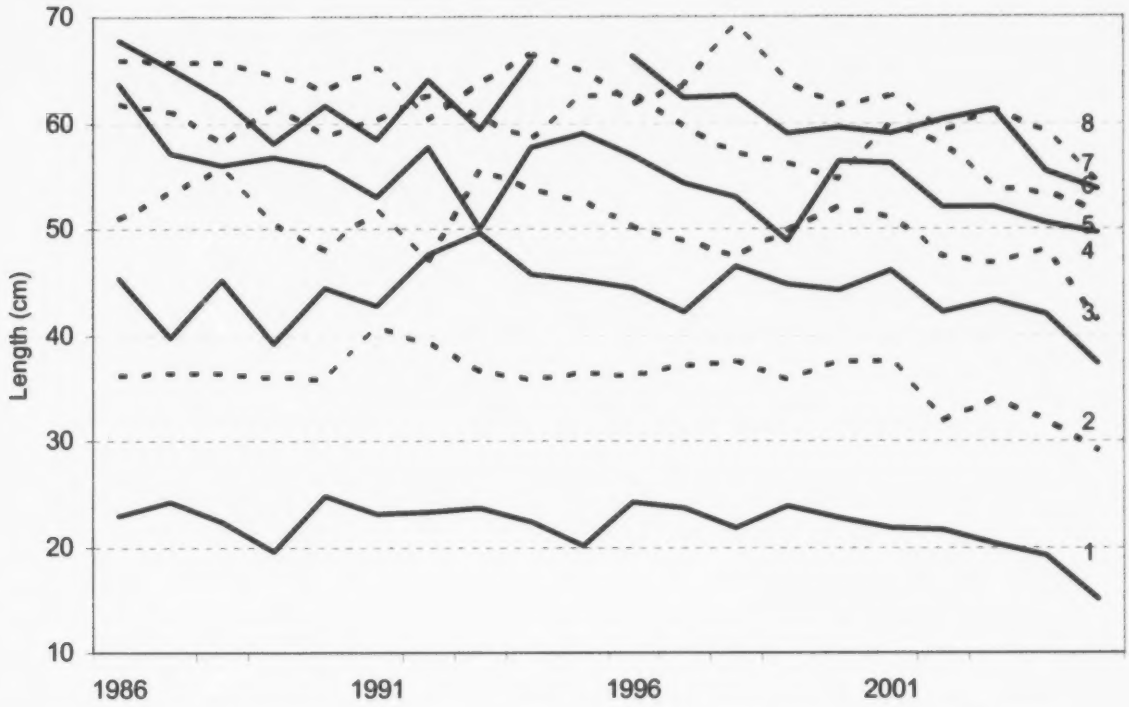

Figure 19. Length at age for haddock in unit areas 5Zjm derived from DFO surveys during 1986-2005.

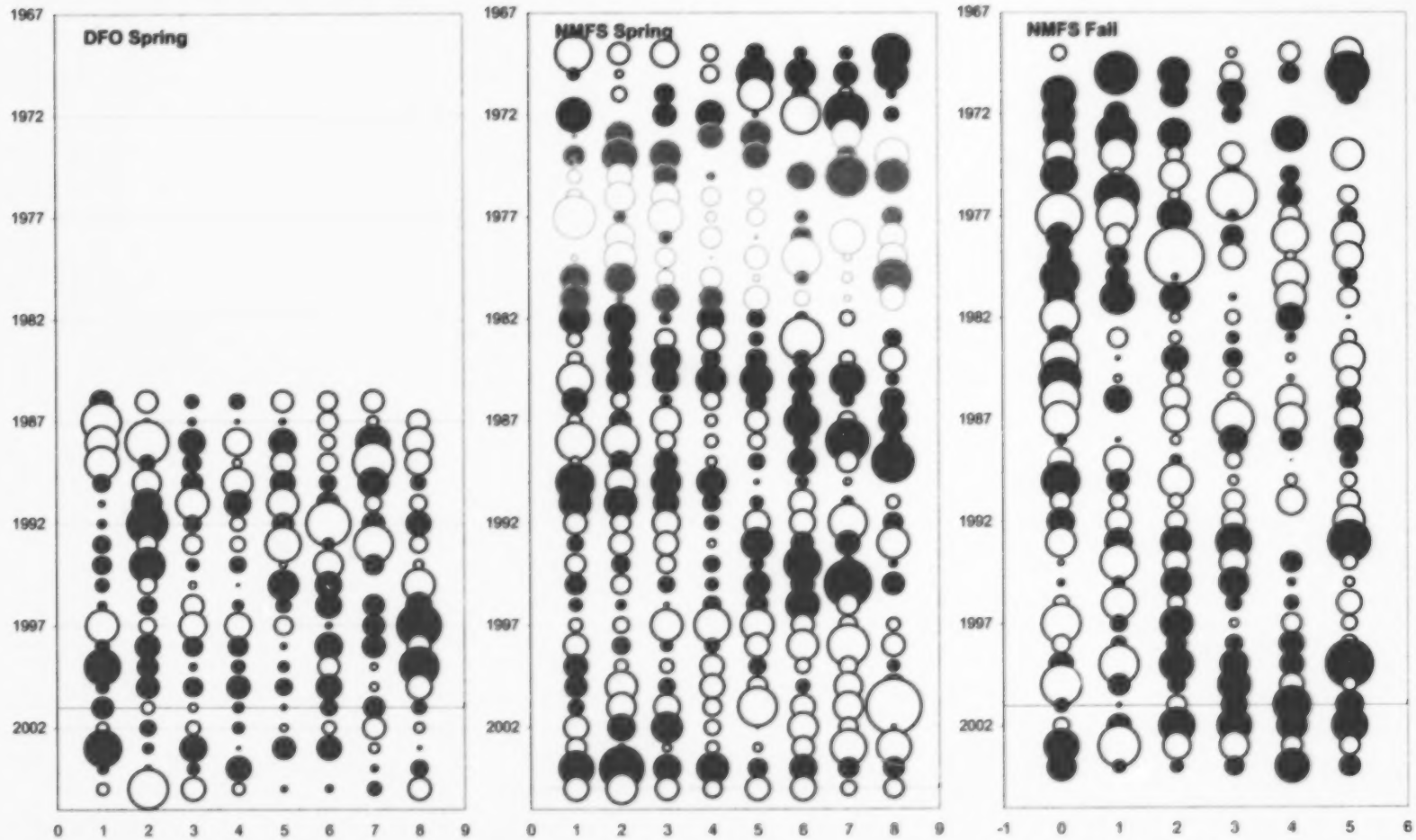

Figure 20. Residuals by year and age group for research survey indices during 1969-2005. Solid symbols indicate positive values, open symbols indicate negative values. Bubble area is proportional to magnitude. From 1973-81 (pale circles), a 41 Yankee trawl was used for the NMFS spring survey while a 36 Yankee was used in the other years.

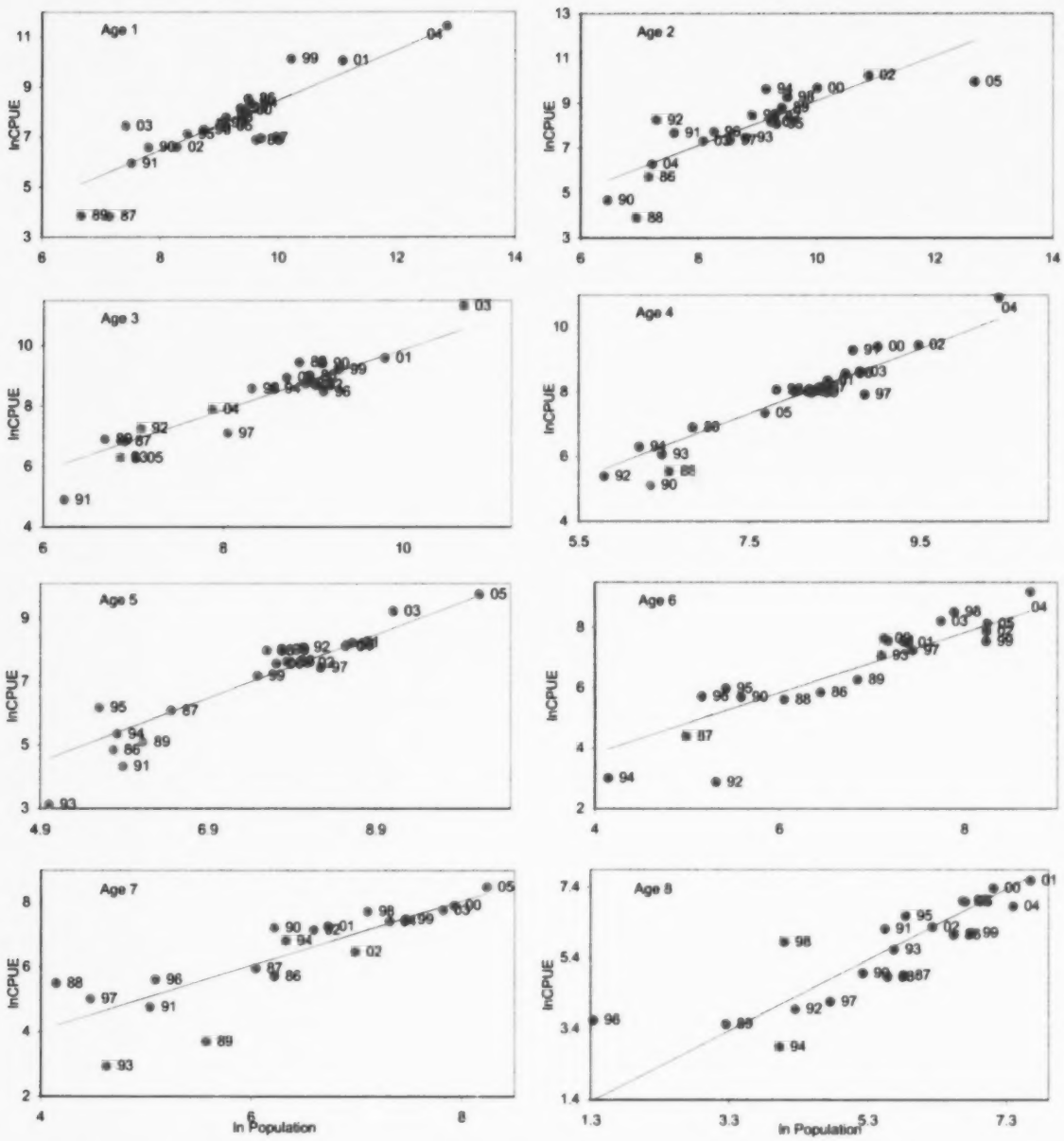

Figure 21. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **DFO** survey during 1986-2005.

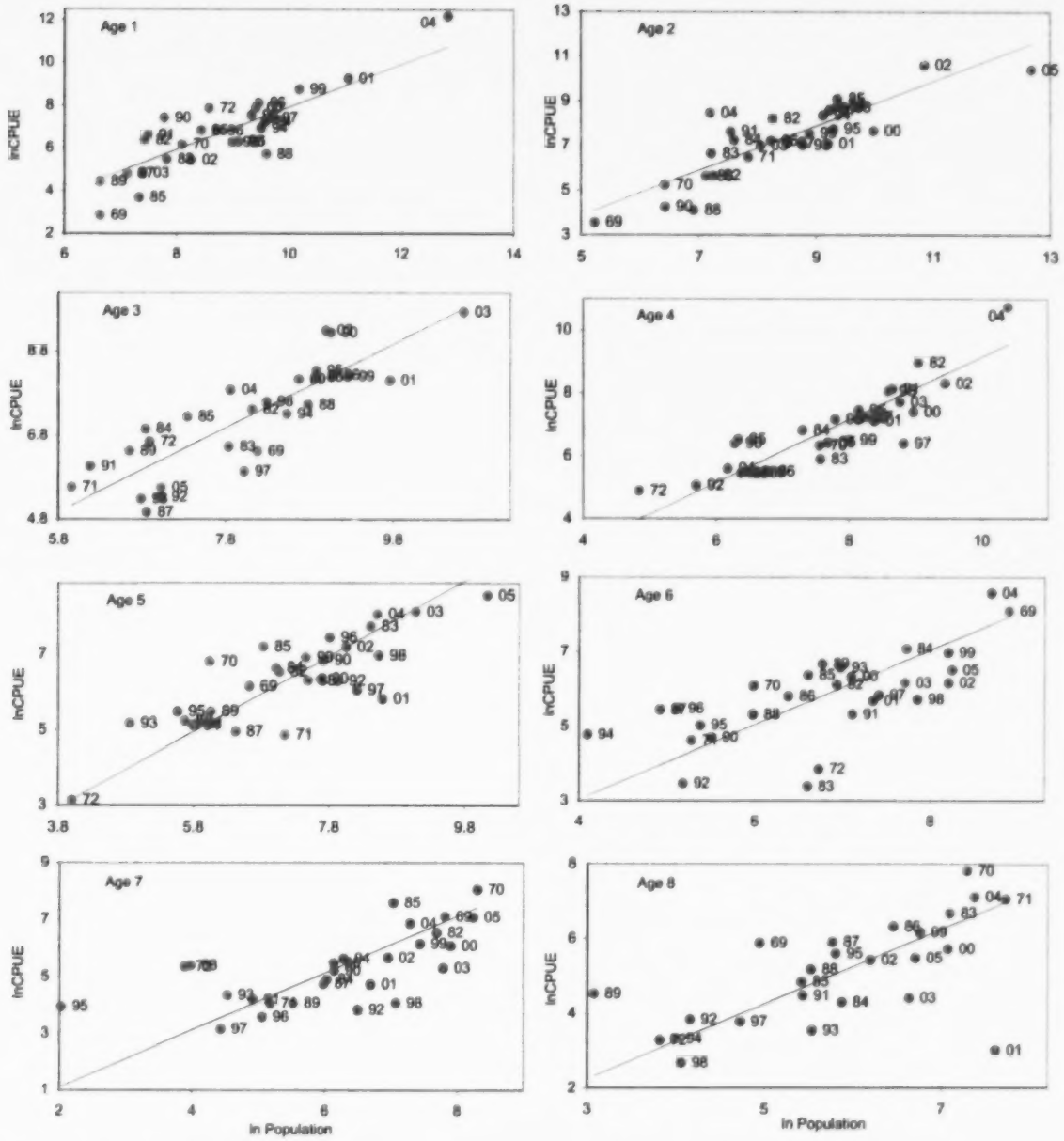

Figure 22. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 36 net during 1969-1972 and 1982-2005.

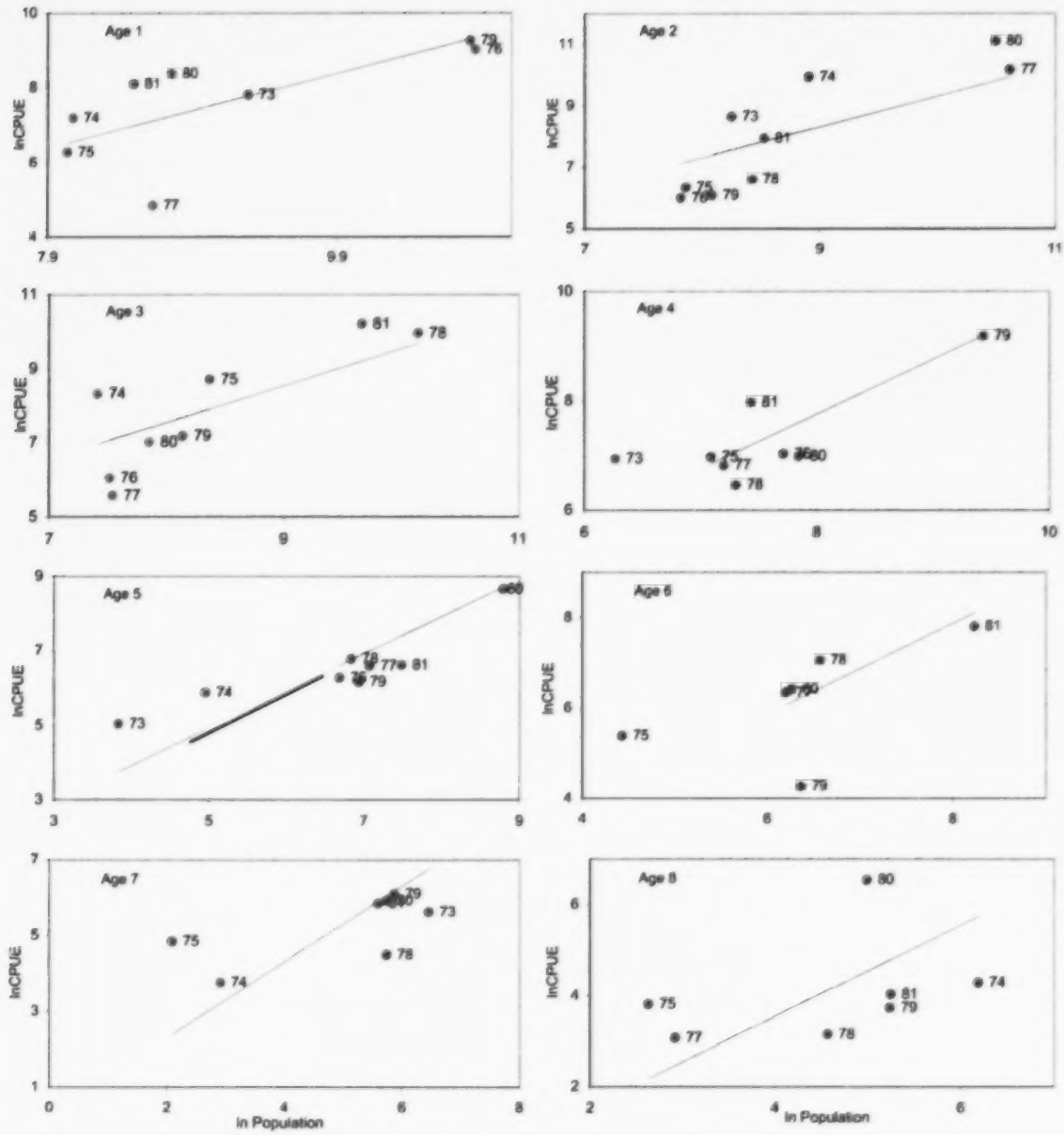

Figure 23. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS spring** survey with a Yankee 41 net during 1973-1981.

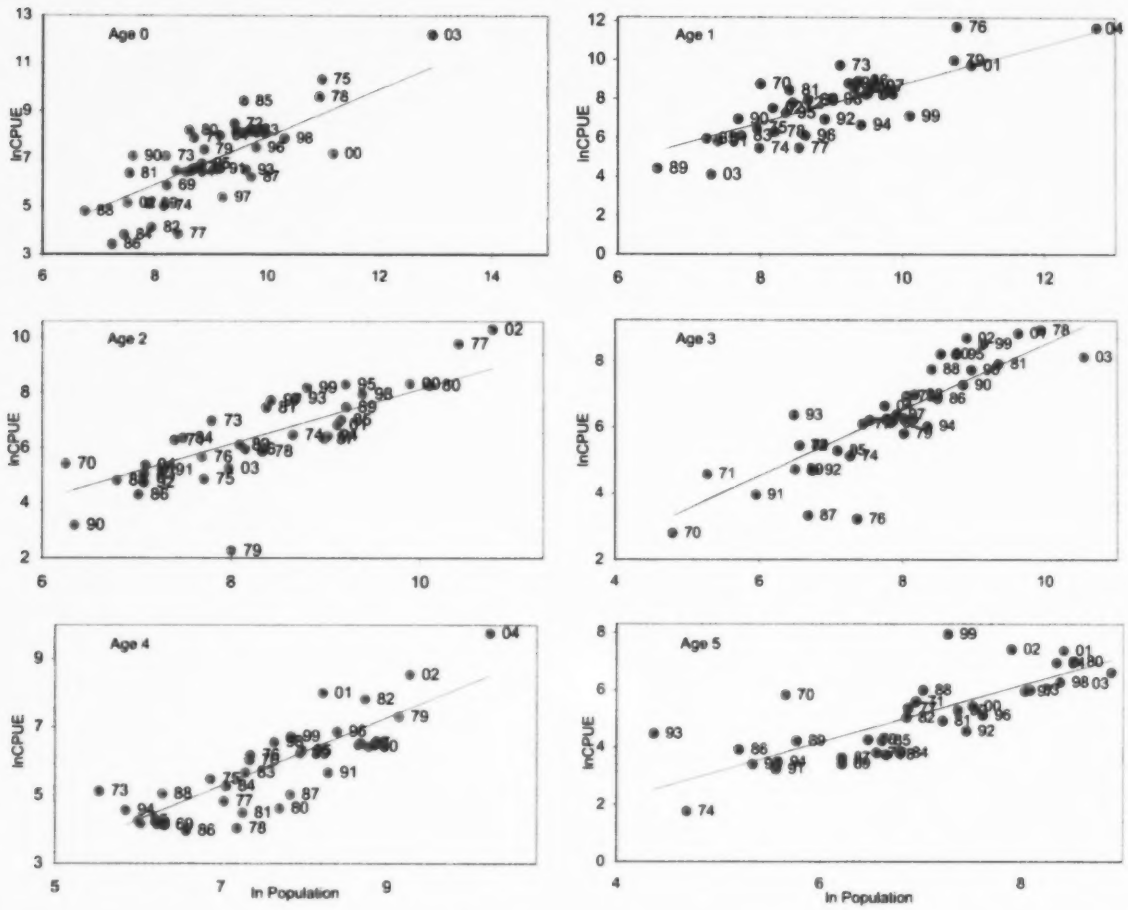

Figure 24. Age by age plots of the observed and predicted ln abundance index versus ln population numbers for haddock in unit areas 5Zj and 5Zm from the **NMFS fall** survey 1969-2004.

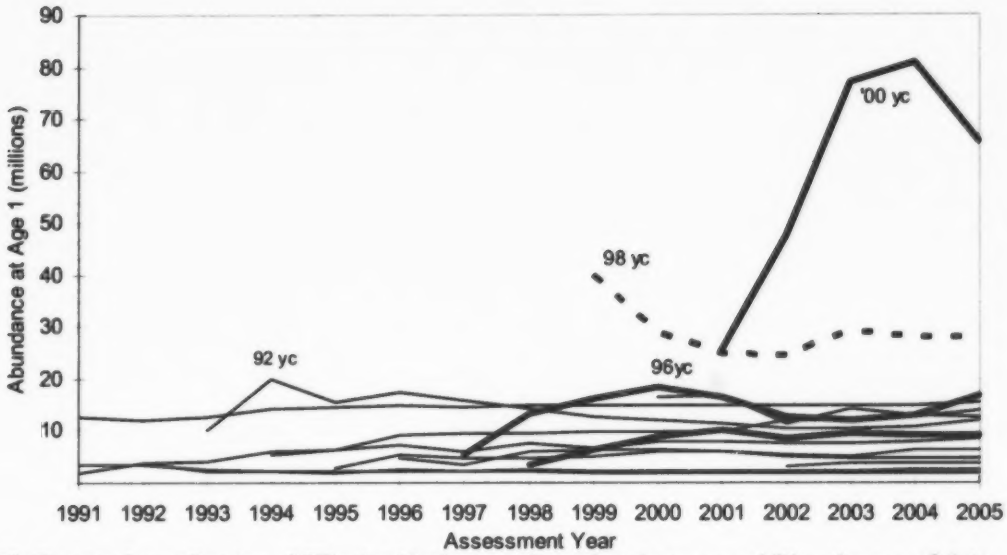

Figure 25. Successive estimates of 5Zjm haddock year-class abundance as additional years of data were included in the assessment did not display any persistent trends.

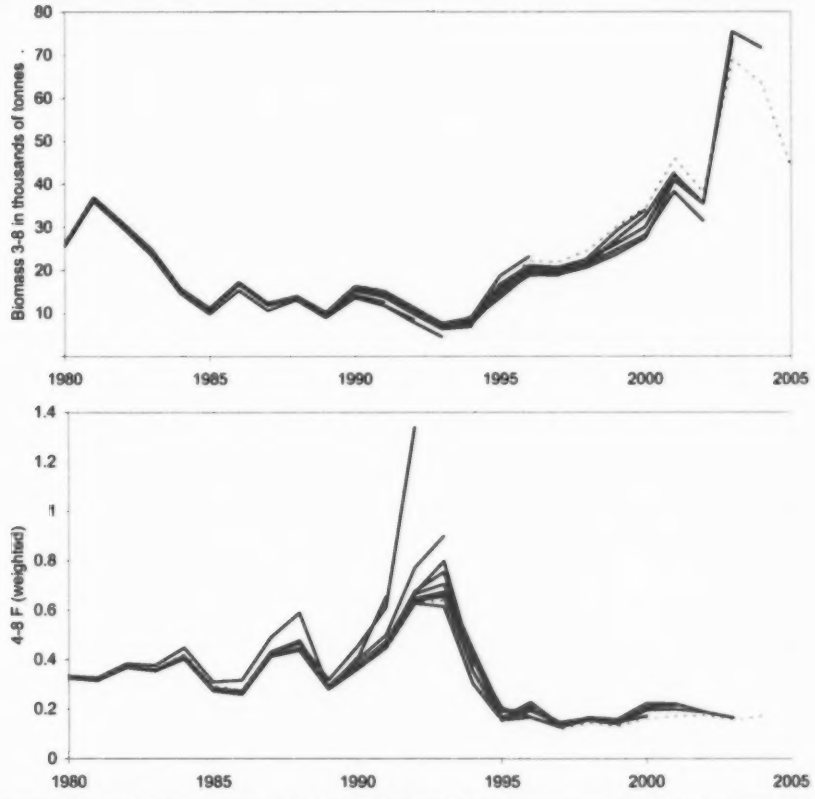

Figure 26. Retrospective estimates from VPA of 5Zjm haddock biomass and fishing mortality did not display any persistent trends for over or under estimation as successive years of data were excluded in the assessment.

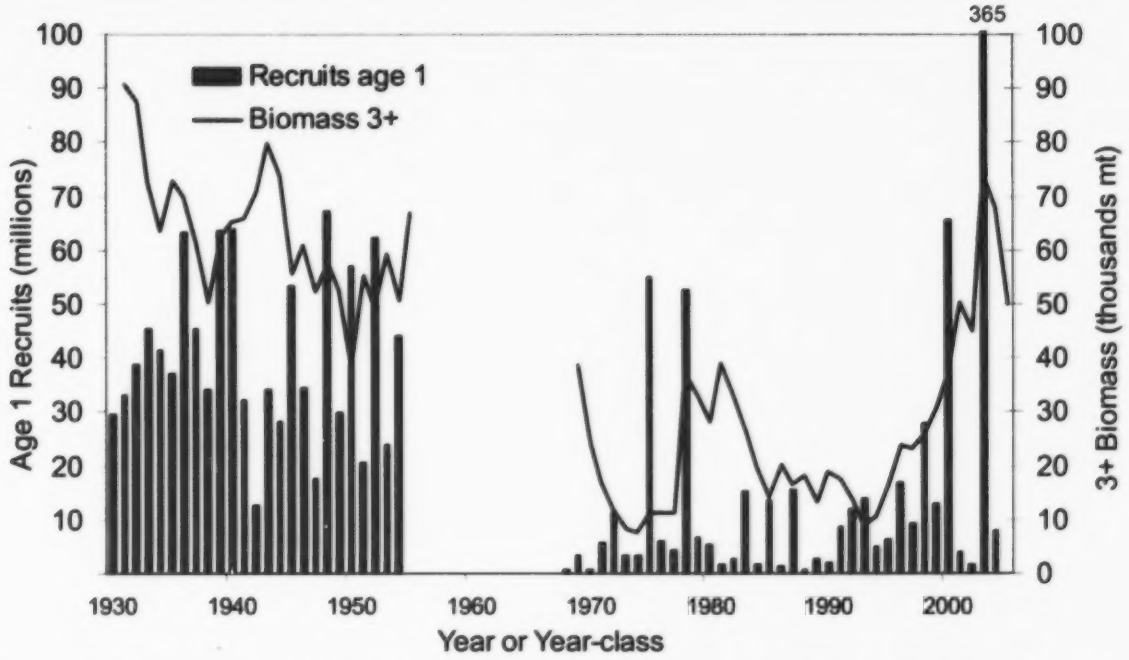

Figure 27. Beginning of year adult (3+) biomass and number of age 1 recruits for haddock in unit areas 5Zjm during 1931-1955 and 1969-2005.

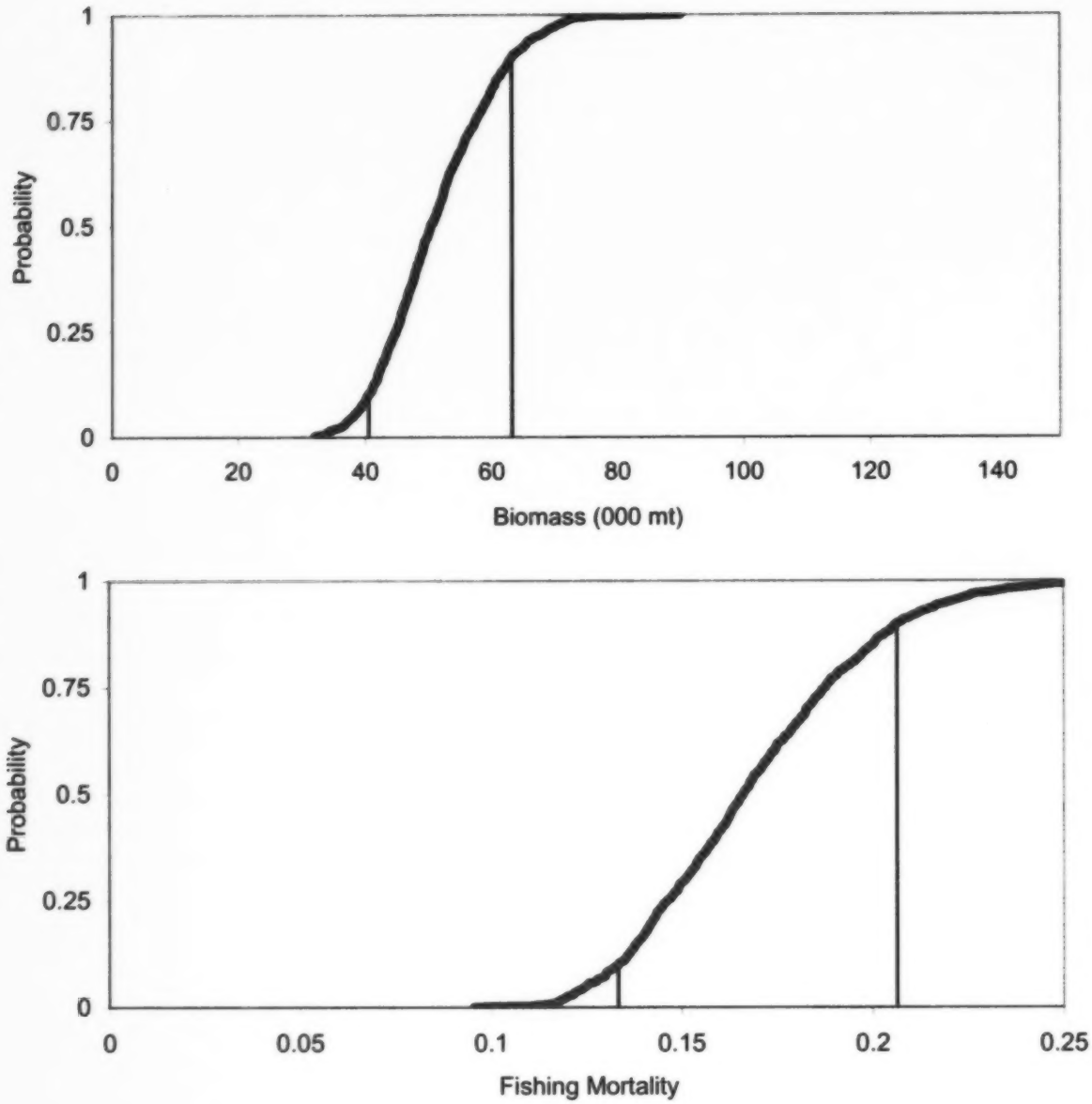

Figure 28. Confidence distribution with 80% confidence intervals for 2005 5Zjm haddock ages 3+ biomass (000 mt) and 2004 ages 4+ fishing mortality.

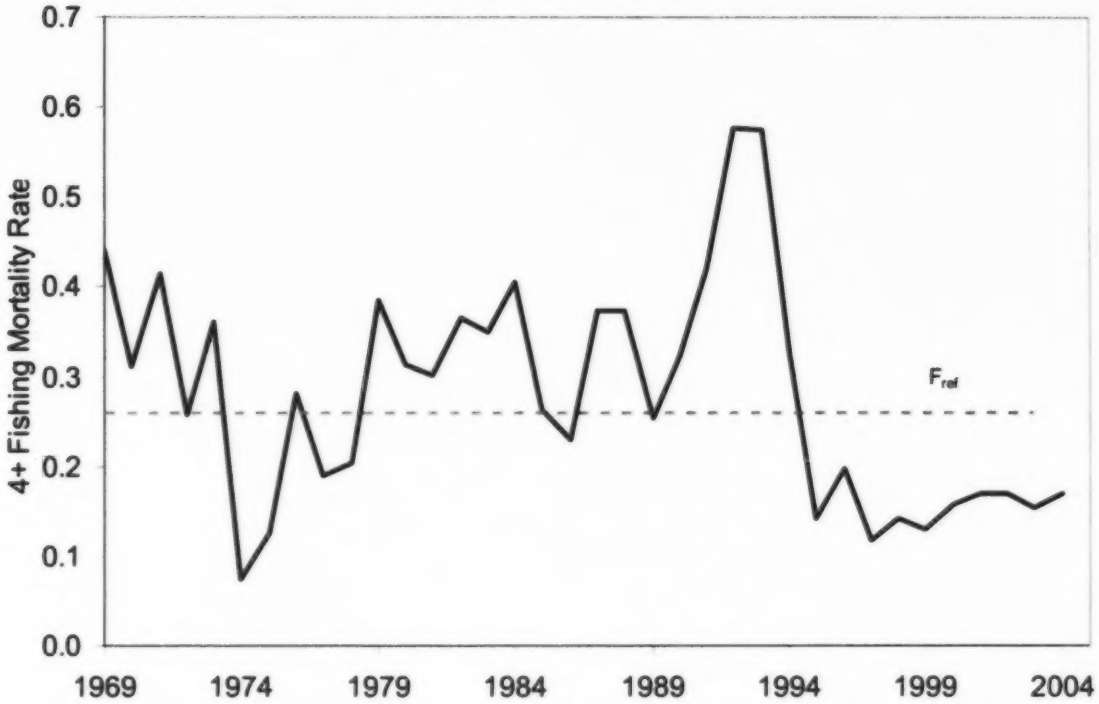

Figure 29. Fishing mortality rate for haddock ages 4+ in unit areas 5Zjm and the fishing mortality threshold reference established at F_{ref} = 0.26 during 1969-2004.

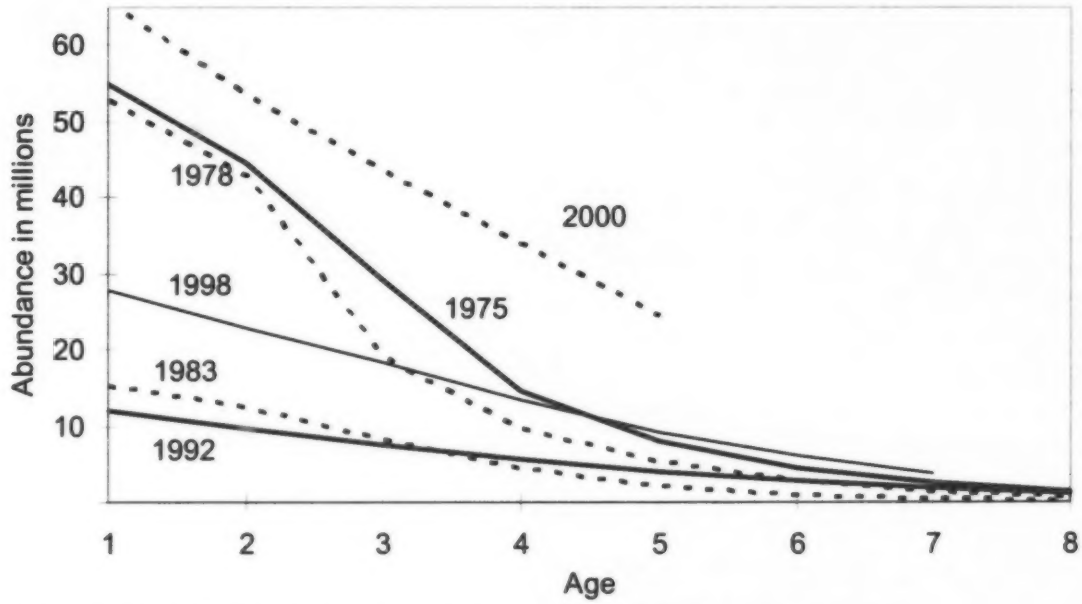

Figure 30. Decline in abundance of selected year-classes of the 5Zjm haddock population.

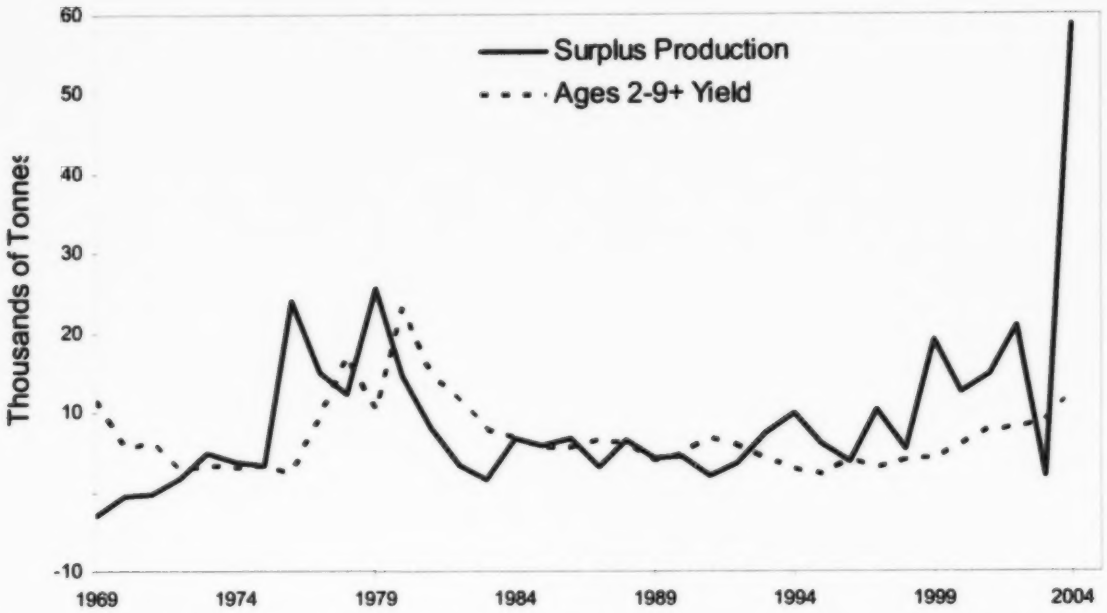

Figure 31. Surplus production of 5Zjm haddock available to the commercial fishery compared to the harvested yield during 1969-2004.

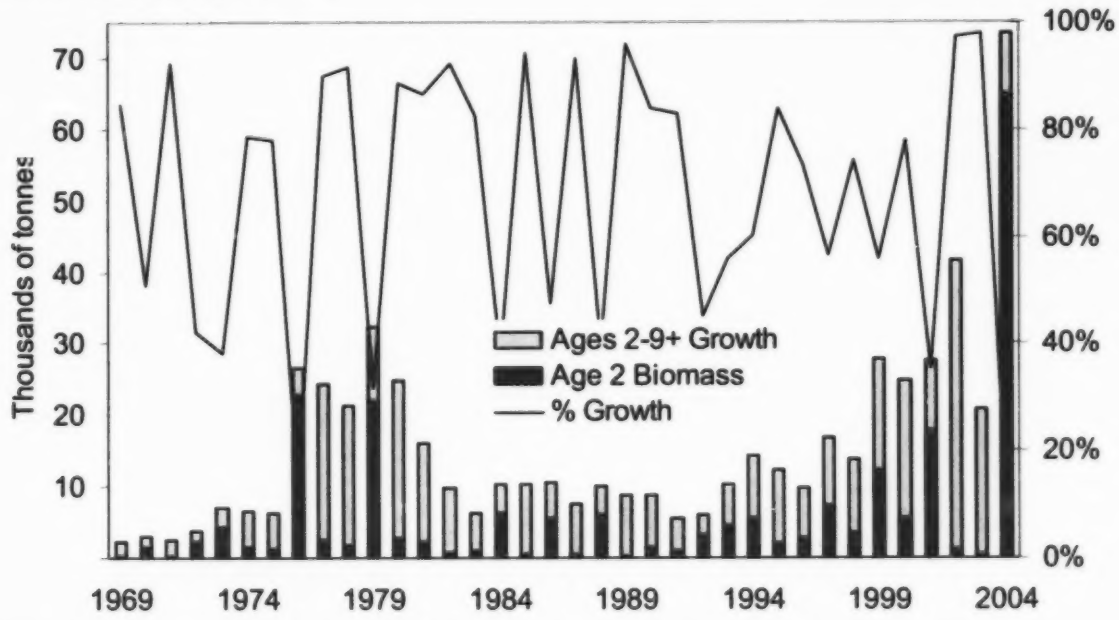

Figure 32. Amount of productivity attributible to growth (ages 2 to 9+) of 5Zjm haddock and the amount contributed by recruitment (age 2) during 1969-2004.

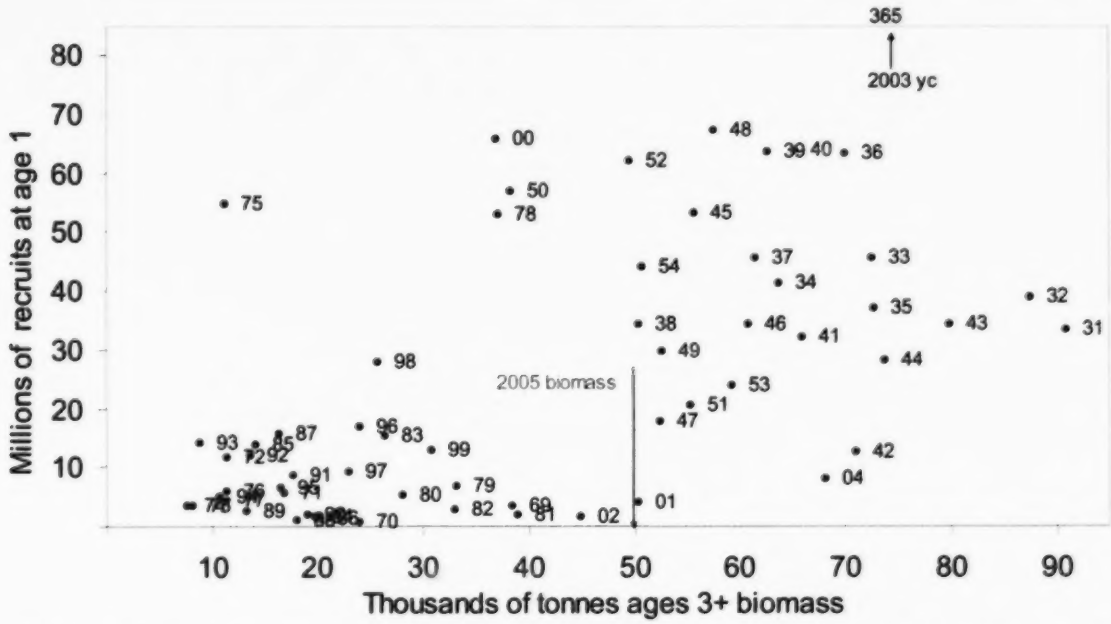

Figure 33. Relationship between adult (ages 3+) 5Zjm haddock biomass and recruits at age during 1931-1955 and during 1969-2004.

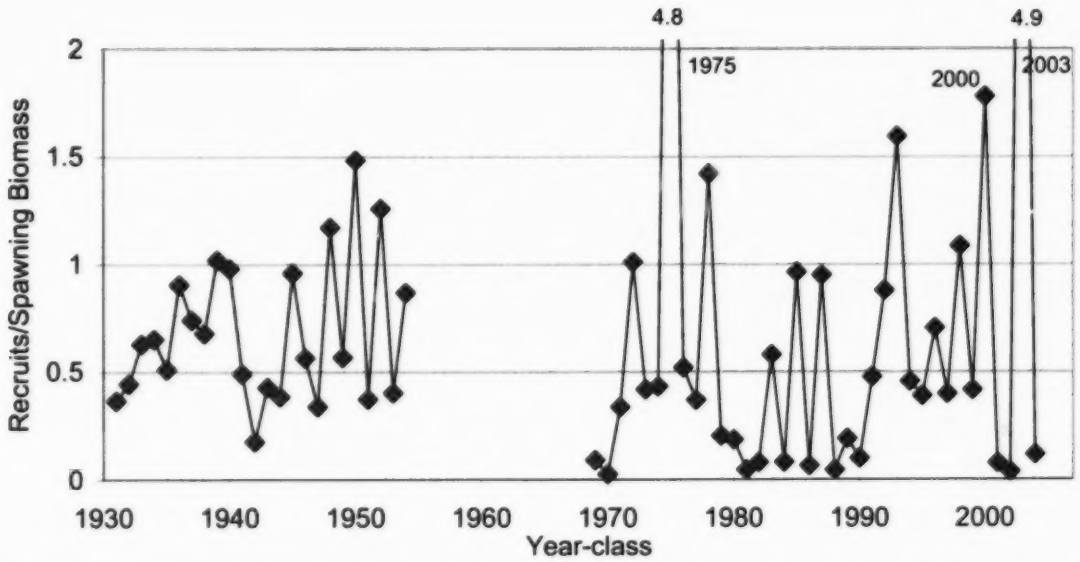

Figure 34. Ratio of recruits (numbers at age 1) to spawning biomass (kg) for 5Zjm haddock during 1931-1955 and during 1969-2004.

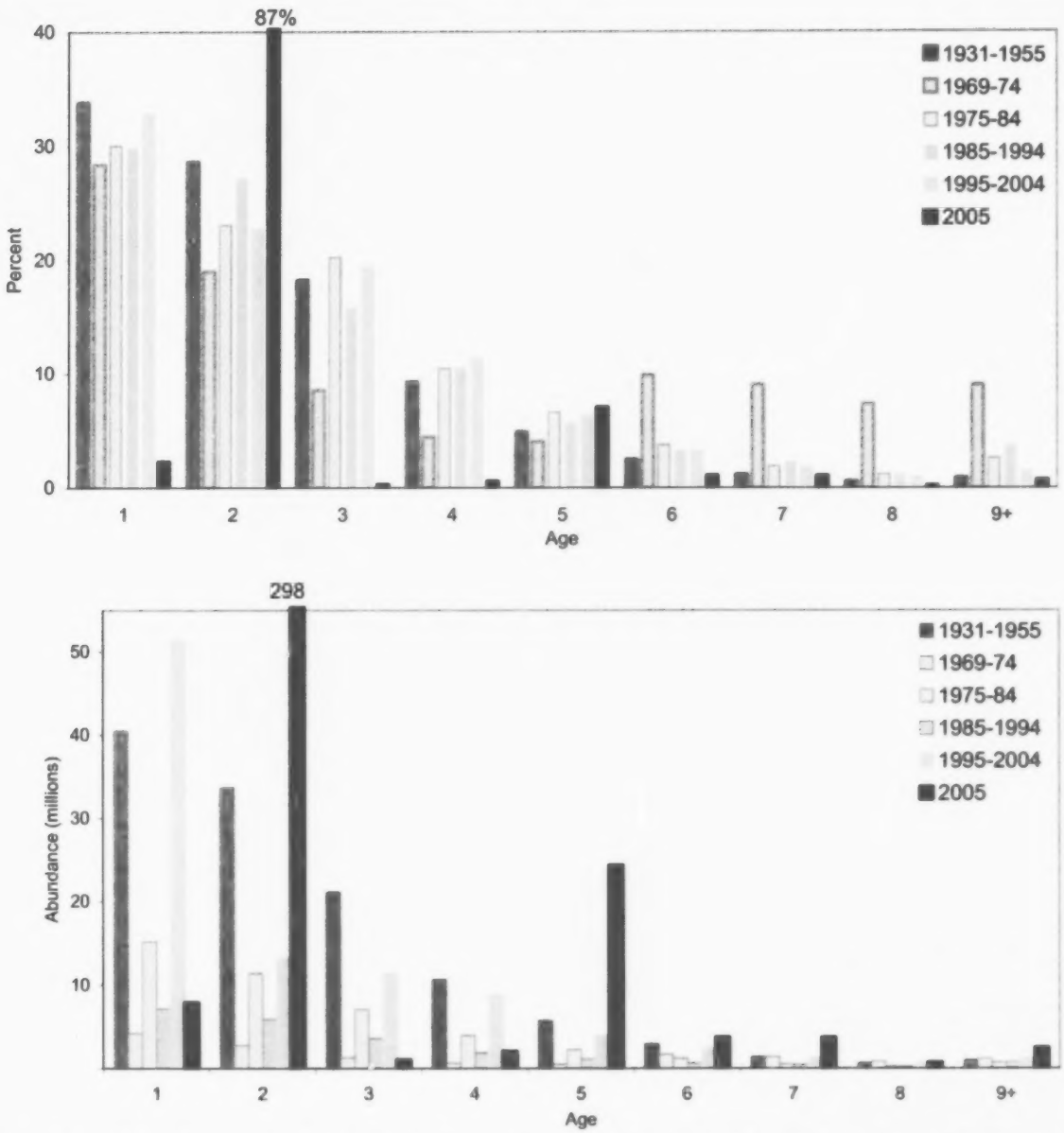

Figure 35. The age composition and absolute abundance at age of the 5Zjm haddock population in 2005 compared to averages during 1931-1955, 1969-1974, 1975-1984, 1985-1994, and 1995-2004.

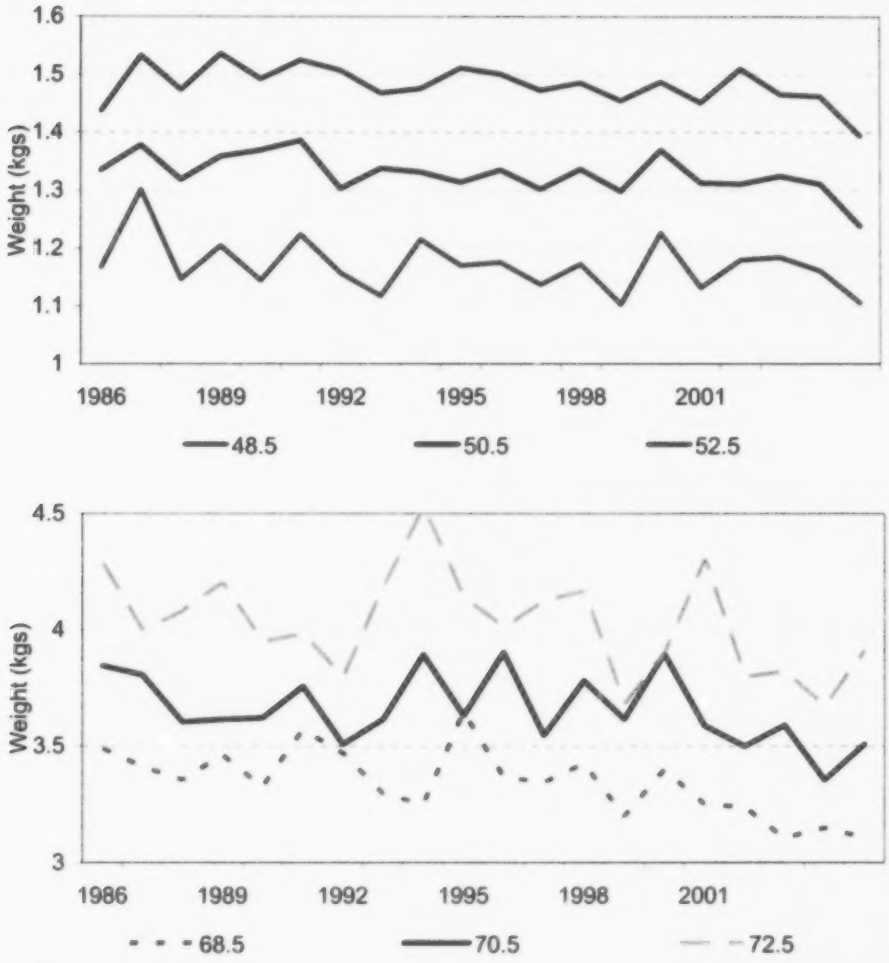

Figure 36. DFO survey weights at lengths for haddock in 5Zjm for six 2 cm length groupings during 1986-2005.

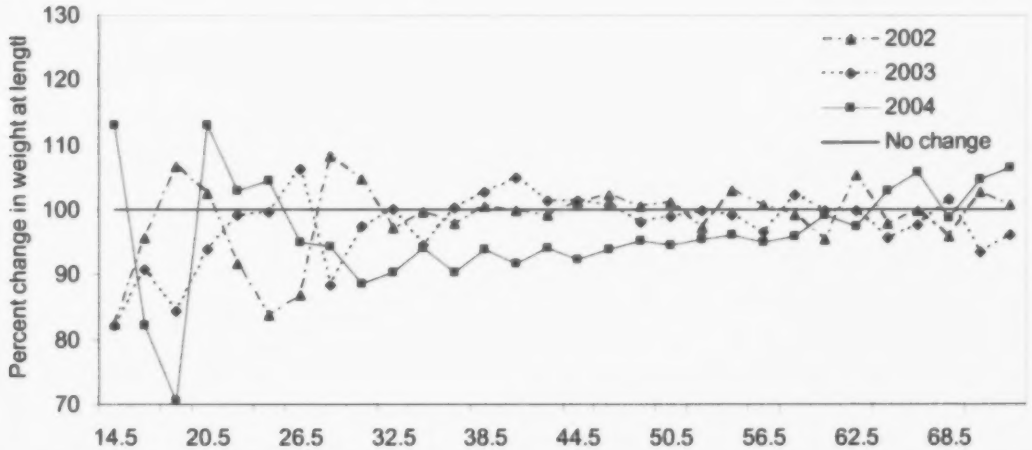

Figure 37. Percent change in DFO survey weight at length for haddock in 5Zjm during 2002, 2003 and 2004.

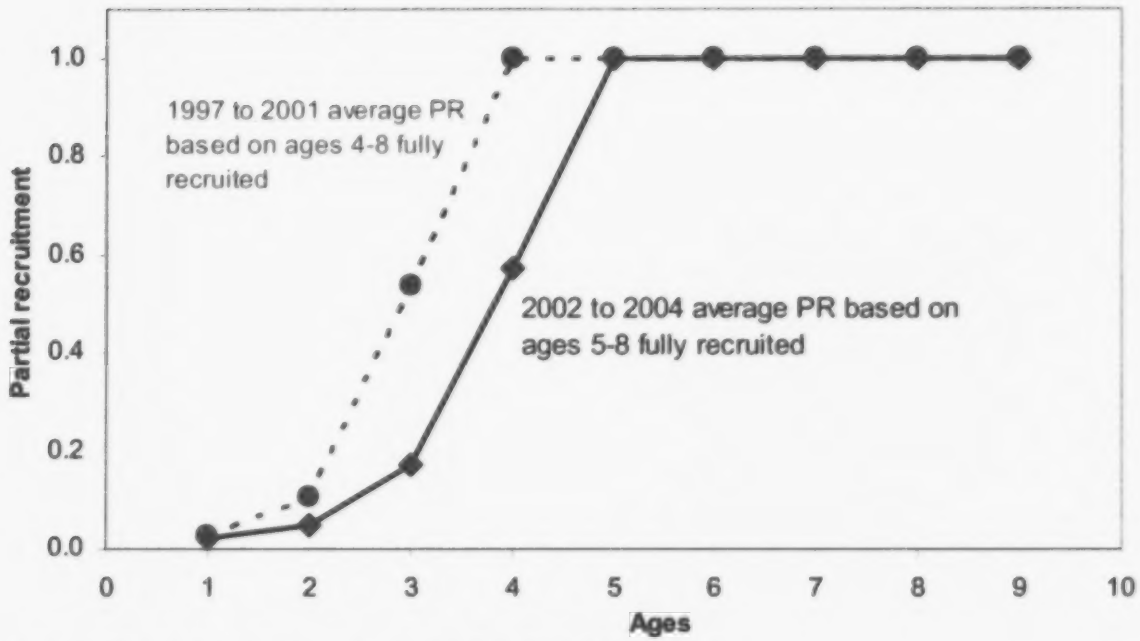

Figure 38. Change in average recruitment pattern for 5Zjm haddock.

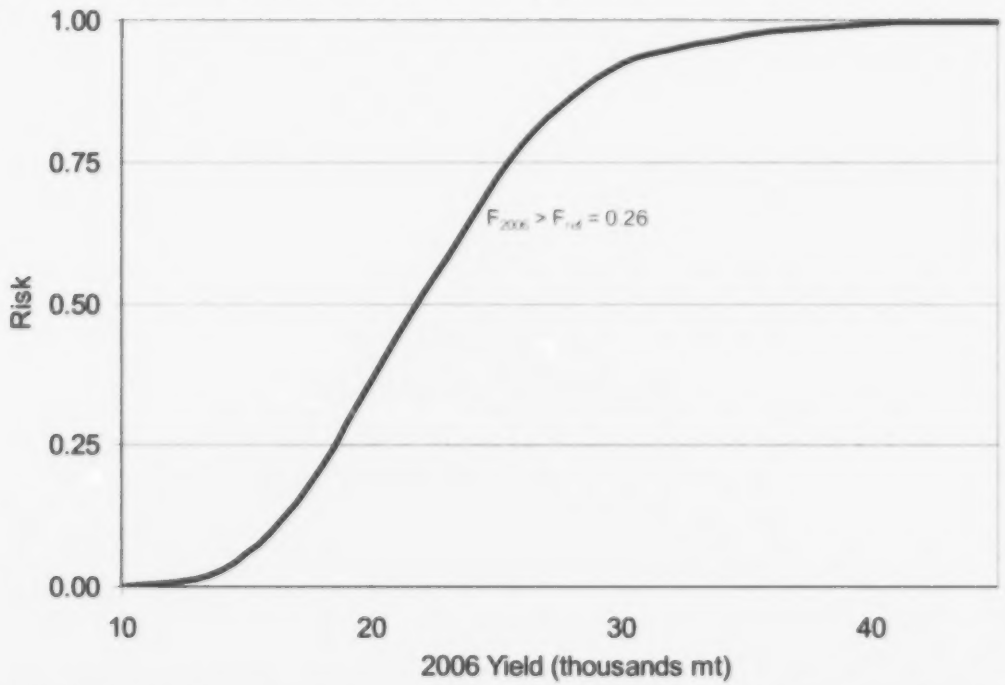

Figure 39. Risk of 2006 fishing mortality exceeding F_{ref} = 0.26 for 5Zjm haddock for increasing catch quotas. The 2002-2004 average fishery weights at age and partial recruitment pattern were used to predict the yield and the 2005 DFO average survey weights at age were used to estimate beginning year population biomass.

Appendix A

Table A1. Intra-reader agreement matrix for the NMFS haddock age reader, S. Sutherland, using 5Z haddock otoliths from the NMFS 2004 fall survey.

NMFS 2004 Fall Survey		Test Age																	
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Production Age	0	8																	8
	1		28																28
	2			1															1
	3				3														3
	4				1	29													30
	5					2	2												4
	6						1	15											16
	7								3										3
	8									6									6
	9									1	1								2
	10											1							1
	11																		
	12																		
	13																		
	14																		
	15																		
	16																		
	Total	8	28	1	4	31	3	15	3	7	1	1							102
Percent agreement = 97/102 = 95.1%																			

Table A2. Intra-reader agreement matrix for the NMFS haddock age reader, S. Sutherland, using 5Z haddock otoliths from the NMFS 2005 spring survey.

NMFS Spring 2005 Survey		Test Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Production Age	0																		
	1		2																2
	2		1	39															40
	3				1														1
	4					4													4
	5						11												11
	6							5											5
	7							1	9										10
	8								1	1									2
	9										1								1
	10																		
	11																		
	12																		
	13																		
	14																		
	15																		
	16																		
	Total		3	39	1	4	11	6	10	1	1								76
Percent agreement = 73/76 = 96.1%																			

Table A3. Intra-reader agreement matrix for the NMFS haddock age reader, S. Sutherland, using 5Z haddock otoliths from the 2004 quarter 1 USA commercial fishery.

2004 Quarter 1 USA Commerical Fishery		Test Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Production Age	0																		
	1																		
	2																		
	3																		
	4					4													4
	5						3	1											4
	6							22											22
	7								7	2									9
	8									7									7
	9										2								2
	10											3							3
	11											1	4						5
	12																		
	13																		
	14																		
	15																		
	16																		
	Total					4	3	23	7	9	2	4	4						56
Percent agreement = 52/56 = 92.9%																			

Table A4. Intra-reader agreement matrix for the NMFS haddock age reader, S. Sutherland, using 5Z haddock otoliths from the 2004 quarter 2 USA commercial fishery.

2004 Quarter 2 USA Commerical Fishery		Test Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Production Age	0																		
	1																		
	2																		
	3																		
	4					7													7
	5						9												9
	6						1	27											28
	7							2	2										4
	8								1	3									4
	9											1							1
	10											1							1
	11												1						1
	12																		
	13																		
	14																		
	15																		
	16																		
	Total					7	10	29	3	3		2	1						55
Percent agreement = 50/55 = 90.9%																			

Table A5. Intra-reader agreement matrix for the NMFS haddock age reader, S. Sutherland, using 5Z haddock otoliths from the 2004 quarter 3 USA commercial fishery.

2004 Quarter 3 USA Commerical Fishery		Test Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Production Age	0																		
	1																		
	2																		
	3																		
	4					10													10
	5						3												3
	6							14	1										15
	7								6										6
	8									3									3
	9																		
	10											4							4
	11												3						3
	12																		
	13																		
	14																		
	15																		
	16																		
	Total					10	3	14	7	3		4	3						44
Percent agreement = 43/44 = 97.7%																			

Table A6. Intra-reader agreement matrix for the NMFS haddock age reader, S. Sutherland, using 5Z haddock otoliths from the 2004 quarter 4 USA commercial fishery.

2004 Quarter 4 USA Commerical Fishery		Test Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Production Age	0																		
	1																		
	2																		
	3				1														1
	4					17													17
	5						5	1											6
	6							24											24
	7								3										3
	8									2									2
	9										2								2
	10											1	2						3
	11												1						1
	12													1					1
	13																		
	14																		
	15																		
	16																		
	Total				1	17	5	25	3	2	2	1	3	1					60
Percent agreement = 57/60 = 95.0%																			

Table A7. Intra-reader agreement matrix for the NMFS haddock age reader, S. Sutherland, using 5Z haddock otoliths from the NMFS reference collection.

NMFS Reference Collection		Test Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Reference Age	0																		
	1		9																9
	2			14															14
	3			3	22	1													26
	4					25	1												26
	5						13												13
	6							8											8
	7								3										3
	8									5	1								6
	9																		
	10																		
	11												1						1
	12														1				1
	13																		
	14																		
	15																		
	16																		
	Total		9	17	22	26	14	8	3	5	1		1		1				107
Percent agreement = 100/107 = 93.5%																			

Table A8. Inter-reader agreement matrix for the NMFS haddock age reader versus the DFO haddock age reader, S. Sutherland and L. Van Eeckhaute, respectively, using 5Z haddock otoliths from the 2004 Canadian fishery.

Canadian Fishery 2004		NMFS Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
DFO Age	0																		
	1																		
	2			1															1
	3				1														1
	4					19													19
	5						5												5
	6						1	8											9
	7								3										3
	8									3									3
	9									1	2								3
	10											3							3
	11												1						1
	12													1					1
	13														1				1
	14																		
	15																		
	16																		
	Total			1	1	19	6	8	3	4	2	3	1	1	1				50
Percent agreement = 48/50 = 96.0%																			

Table A9. Inter-reader agreement matrix for the NMFS haddock age reader versus the DFO haddock age reader, S. Sutherland and L. Van Eeckhaute, respectively, using 5Z haddock otoliths from the 2004 DFO survey.

2004 DFO Survey		NMFS Age																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
DFO Age	0																		
	1		10																10
	2			5															5
	3				2														2
	4					12													12
	5						2												2
	6							4											4
	7								3										3
	8									2									2
	9									1	2								3
	10																		
	11												1						1
	12																		
	13																		
	14														1				1
	15																		
	16																		
	Total		10	5	2	12	2	4	3	3	2		1		1				45
Percent agreement = 43/45 = 95.6% (5 omitted)																			